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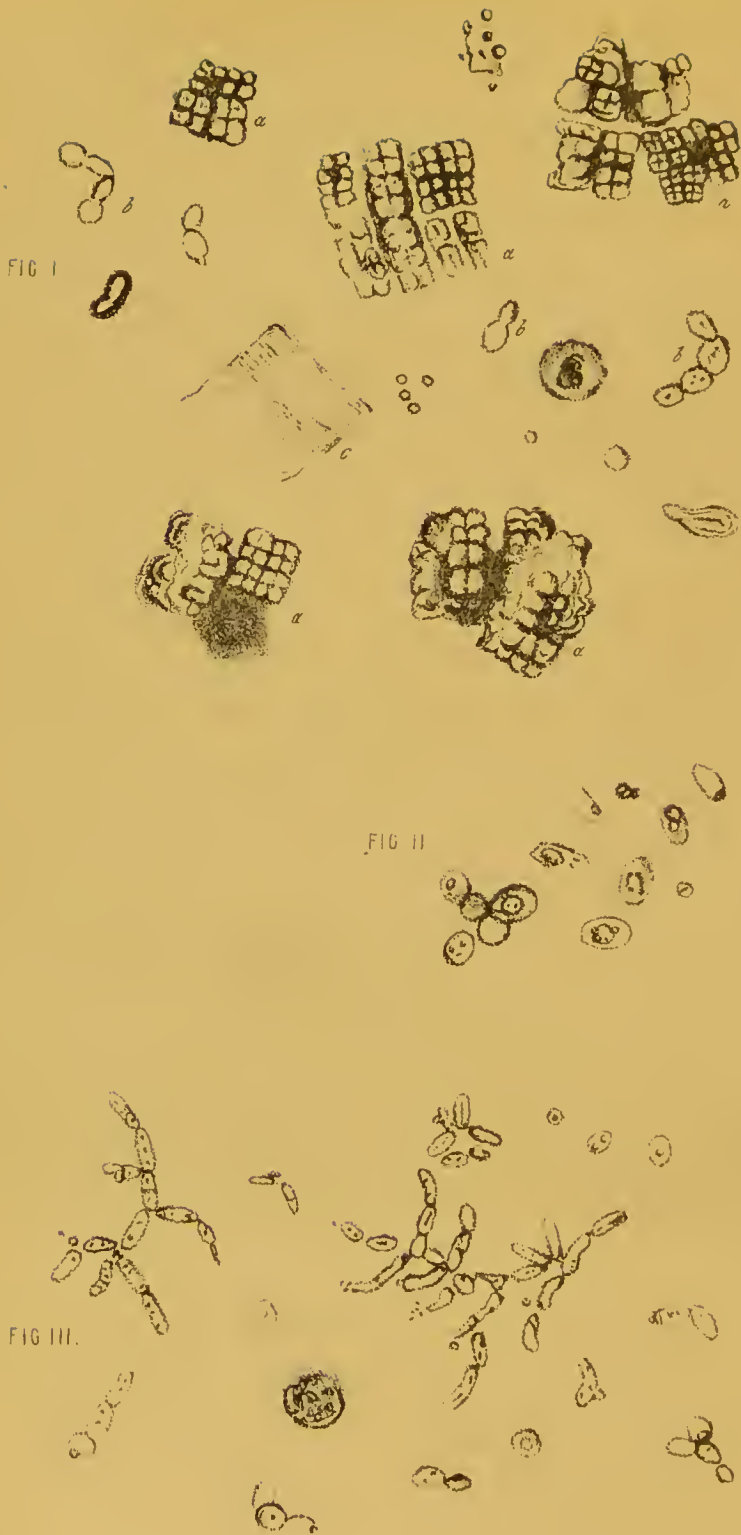


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Sarcina Ventriculi, Torula and Penicillium Glancum.
(See explanation of Plate)

A

PRACTICAL TREATISE

ON

DISORDERS OF THE STOMACH

WITH

FERMENTATION;

THE CAUSES AND TREATMENT OF INDIGESTION;

AND ON

D I E T.

BY

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P R E F A C E.

MY attention having been directed to disorders of the stomach arising from fermentive actions, I have been led to investigate the subject, and to observe that disorders of this nature form a much larger and more important class than is generally believed; that, in fact, fermentive actions have more or less connexion with almost all the disorders, as well as the organic diseases which occur in the digestive canal. But though the subject is one of so much practical importance, it has been only incidentally noticed even in some of the most recent works, and as yet there is no treatise in which fermentive disorders of the stomach and bowels are made the subject of special investigation in all their bearings.

I have therefore thought that a treatise having such

an object in view might not be unacceptable at the present time, and, though professional engagements have prevented me rendering it as complete in many points as I would wish, I trust that it will at least have the effect of directing attention to the subject, of leading those in practice to view these disorders in a light in which they have hitherto been but little examined, and also of proving in some measure that chemical facts admit of more extended practical application in the advancement of medical knowledge.

The work, it will be found, is divided into six chapters. In the first, I have briefly examined Natural Digestion, and have endeavoured to point out how far we have reason to believe that actions of fermentive nature perform a part in the healthy process.

In the second, I have examined the Chemistry of Fermentation, but this is a subject which has not yet been so fully and exactly studied by the scientific chemist as we could wish, or so as to admit of it being fully applied practically to medical purposes. In this chapter will also be found the results of some researches I have made as to the effects of certain chemical agents in arresting fermentive actions.

The third chapter is devoted to an examination of that peculiar form of disorder of the stomach in which there is vomiting of fermenting matter containing the

remarkable microscopic plant called the *sarcina ventriculi*, which has of late attracted so much notice.

In the fourth chapter, the dyspeptic disorders arising from other fermentive actions are examined, and also the conditions of the stomach and its mucous membrane which tend to induce these morbid actions, and such disorders as acidity, heartburn, pain at the stomach, and vomiting.

In the fifth chapter the treatment of these dyspeptic disorders is considered, and the action of various remedies investigated. It will also be found that one very interesting fact has been brought to light by my researches into the power of different antifermentive agents, viz., that amongst the remedies which have been discovered to be most useful in relieving dyspeptic disorders, are found several of those chemical agents which have most energetic antifermentive properties.

The last chapter is devoted to the examination of diet in relation to the tendency of various articles of food and drink to promote or prevent fermentive actions. It is also shown that many of the seasoning agents used with our food have the power of stopping fermentation, and that mustard and horse-radish are agents of this kind, which owe their value as condiments to their antifermentive properties.

To the kindness of Mr. Fletcher I am indebted for the drawing of the microscopic plants which have been found to occur in the contents of the stomach.

Mornington Terrace, Liverpool,
June, 1856.

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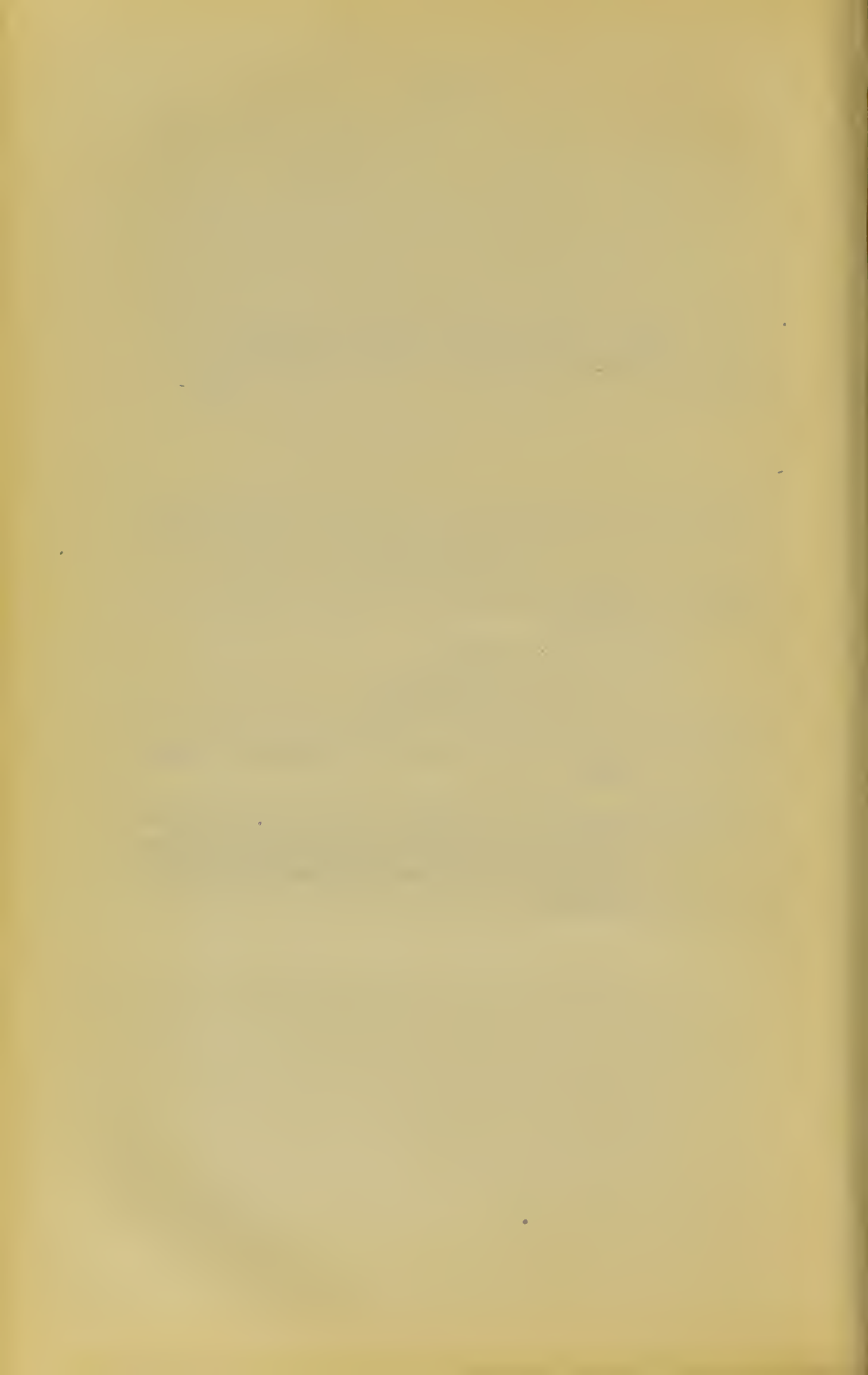
a. a. a. *Sarcina Ventriculi*.

b. b. *Torula*, or Yeast Plant.

C. Piece of Muscular Fibre.

Figure II. — Cells of *Torula*, as seen in a Specimen of German
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had undergone Vinous and subsequently Acetous Fer-
mentation.



PRACTICAL TREATISE,

&c. &c.

CHAPTER I.

NATURAL OR HEALTHY DIGESTION.

PRELIMINARY OBSERVATIONS ON THE CONNECTION OF FERMENTIVE ACTIONS WITH DIGESTION. — ACTION OF SALIVA ON STARCH. — THE GASTRIC JUICE. — ITS ACIDITY. — ITS PEPSIN FERMENT. — DIGESTION OF ALBUMINOUS FOOD IN THE STOMACH. — THE PANCREATIC JUICE. — ITS ACTION ON STARCH. — ON FAT. — THE BILE. — ITS ANTI-FERMENTIVE PROPERTIES. — THE INTESTINAL JUICE. — ITS SOLVENT ACTION ON ALL KINDS OF FOOD.

THERE are few medical subjects on which more has been written than the derangements of digestion. It might therefore seem a hopeless task to bring forward anything novel in respect to indigestion, or even to place the facts already known in a new or interesting point of view. Disorders of the stomach have presented a wide field for conjecture and empiricism; this having arisen from the fact that but little light has been thrown upon them by pathological researches, the majority being of a functional nature, and requiring the aid of other modes of investigation. There is, however, one class which, though recognised by recent writers, has not yet received the special notice it deserves, and to which my attention has been directed

in consequence of meeting with several cases of the remarkable disorder attended with fermentation and the generation in the stomach of the peculiar fungus or plant called the *Sarcina ventriculi*. The disorders arising from fermentive actions produce many of the most common forms of dyspepsia; and as they constitute a distinct class, arising from abnormal actions of a chemical nature, we shall, in the following pages, examine them in connection with each other.

The advances which have of late years been made in medical science have tended to show that many of the processes of living beings are due much less to vital forces, and are more dependent on chemical and physical actions, than was formerly supposed. This observation holds true more especially in respect to the function of digestion, by which the food is dissolved and prepared for absorption into the blood. There is no function the right performance of which is more important to the comfort and well-being of the individual than this, which is more a chemical than a vital process; and there is none from derangement of which a greater number of diseases derive a hidden origin.

The various kinds of fermentation are chemical processes, which exercise a wide spread influence in producing changes in organic matters of animal as well as vegetable nature. We know that the first changes which the food undergoes in the digestive organs are of a fermentive kind, and it is by a process of fermentation that we prepare some of the commonest articles of food, so as to lessen the labours of the stomach, and enable it to extract more completely the whole of the nutriment they contain. I need only mention the preparation of bread by the fermentation of flour, and of fermented liquors, such as wine from the juice of the grape, by which means a kind of liquid food is obtained which has already undergone such complete prepara-

tion that it is absorbed without the necessity of further digestion, and therefore quickly restores the exhausted bodily powers.

In almost every stage in the process of digestion we shall see that the food is subjected to influences tending to the production of certain kinds of fermentation; and it is essential for the right understanding of the abnormal kinds of fermentation which produce heart-burn, acidity, and other forms of indigestion, that we should know what chemical changes the food undergoes during healthy digestion. We shall therefore first examine, as briefly as possible, the changes to which the food is subjected in natural or healthy digestion.

Action of the Saliva. — During mastication the food is intimately mixed with the saliva, a fluid which has the remarkable power of converting starch into sugar by causing the kind of fermentation called the saccharine. The saliva is a mixture of the secretion from the salivary glands, and of the mucus secreted by the mucous glands of the mouth; and the power of converting starch into sugar seems to be possessed by these secretions only when mixed together. It begins to take place in from three to five minutes after the food is mixed with the saliva; and though the saliva is an alkaline fluid, it would appear from Lehmann's observations that its action is not suspended when the food is mixed with the acid secretion of the stomach.

Saliva contains two chief ingredients, on which its properties seem to depend. One of these is the albuminous principle called *ptyalin*, which has been also called salivary diastase from the analogy of its action to that of the diastase or gluten ferment of malt. It exists in the saliva in combination with potash, soda, and lime; and in many respects it is similar to albuminate of soda and casein, though not identical with

either. It is, however, undoubtedly an albuminous compound, and like the diastase of malt, which Liebig considers to be gluten in a certain stage of decomposition, it seems to be in such a state of change that it acts as a ferment. There are many tribes of savage nations which are practically better acquainted with the fermentive power of saliva than those who have recourse to the more civilized modes of exciting this fermentive action by malting and other processes; and it is well known that the South American Indians, and other tribes, prepare from cassava, maize, and other starchy grains and roots, the intoxicating drinks called piworrie, chica mascada, &c., by the disgusting process of chewing, in which the saliva changes the starch into sugar, and afterwards aids in producing vinous fermentation.

The other ingredient contained in the saliva is the sulphocyanide of potassium; but with the uses of this salt we are not yet fully acquainted. Kletzensky seems to have thought that it might prevent fermentive action and the formation of fungous growths in the mouth. I have, however, myself ascertained by experiment that it is not an active agent in stopping vinous fermentation. It is worthy of notice that the quantity of this salt in the saliva is increased by coffee, pepper, salt, and spices, and still more by mustard, garlic, and radishes, but that it is diminished by spirituous drinks. It is also diminished by iodine, and disappears during salivation.

The Gastric Juice. — As soon as the food reaches the stomach, it stimulates the mucous membrane, and causes an exudation from its surface, and from the mucous tubuli, of the fluid called the gastric juice, which is the most important and powerful agent in causing the solution or digestion of the food. This

fluid is clear and transparent, and has some very remarkable chemical properties. It is acid, and contains, besides acid and saline matters, an organic substance called *pepsin*, which is soluble in water, but is precipitated more or less perfectly by alcohol, tannin, corrosive sublimate, and the salts of lead. This is the true digestive principle which, with lactic and hydrochloric acids, causes the solution of the albuminous kinds of food. In two instances opportunities have occurred of observing the action of this fluid on the food through openings in the stomach. The first of these was the well-known case of Alexis St. Martin, a young Canadian, who was accidentally wounded in the side in the year 1822 by the discharge of a musket, and had afterwards a permanent opening in the left side from without into the stomach, through which the operations carried on in this organ might be viewed. The second was the case of an Esthonian peasant called Catherine Kütt, who had a similar opening in the left side. The rare opportunity afforded in both of these cases of closely studying the process of digestion has been fully turned to account, in the former by Dr. Beaumont, and in the latter by Bidder and Schmidt and other German physiologists.

The acidity of the gastric juice is an essential quality, on which its solvent power is mainly dependent; and as two acids, the hydrochloric and the lactic, have both been found by different physiologists in healthy gastric juice, there has been considerable difference of opinion as to whether the acidity in the natural condition is due to one or both of these acids. The fact that they both form, with artificial pepsin and water, a solution capable of dissolving albuminous food, would seem to show that they may both be present together in the stomach, or replace each other. There are other acids, the acetic, butyric, and phosphoric, which have been occasionally

met with in the gastric juice ; but they have not the same energetic solvent power, and cannot be reckoned among the normal constituents. Without entering further into this question, we may state that the weight of evidence would seem to favour the opinion originally held by Dr. Prout, that the hydrochloric is the acid secreted with the gastric juice, on which its solvent power chiefly depends, but that the lactic, whether secreted or formed from the food in the stomach, is undoubtedly often present, and serves, more or less perfectly, the same purpose.

Pepsin is obtained artificially from the glandular structure of the stomach, that of the pig being commonly employed ; and it has some remarkable properties requiring further notice. In the moist state it is white and bulky ; when dry it forms a yellow gummy mass, with the odour of glue. Its solvent power is very remarkable. A very minute quantity dissolved in water forms with hydrochloric acid, in the proportion of six drops to the ounce, a liquid which dissolves boiled white of egg at the temperature of 100° in six or eight hours, or, with double the quantity of acid, in two hours. It would appear that the acid is the true solvent, and that the pepsin merely disposes the white of egg to dissolve in the acid ; for by boiling it may be dissolved in an acid fluid alone, exactly as it does under the influence of pepsin, which therefore replaces the effect of a high temperature. Might not this fact be turned to practical account, in the preparation of food capable of being more readily assimilated by weak stomachs in consequence of being boiled with a small quantity of this digestive acid ? Hydrochloric acid with pepsin has a similar action on other kinds of animal food, such as fibrin, meat, and cheese. The acid alone has been found to dissolve only a trifling quantity at the temperature of 100° , but at the boiling point, nearly as much as with pepsin. Was-

man has also found that the pepsin obtained from the stomach of the pig does not coagulate milk, though that obtained from the stomach of the calf possesses this power in a high degree. From this he was led to suppose that the power of rennet depends upon a modification of the pepsin, or upon another substance accompanying it, which is no longer formed when the young animal ceases to be nourished by the milk of its mother.

The following facts stated by Lehmann with respect to the digestive power of the gastric juice are of practical interest, and therefore worthy of notice. "It is suspended by boiling, by saturating the free acid with an alkali or even with phosphate of lime, by sulphurous, arsenious, and tannic acids, by alum and most metallic salts; and it is very much impeded by the addition of alkaline salts, or by saturating the fluid with peptones or other organic fluid substances, either nitrogenous or non-nitrogenous. The addition of water to a gastric fluid, which has been already saturated with a peptone, enables it to digest an additional quantity of protein substances. The digestive power is also restored, to a certain degree, by the repeated addition of free acid. Too much free acid, without due dilution with water, entirely suspends the digestive power. The most favourable ratio of the free acid of the gastric juice is when 100 parts of the latter are saturated by about 1.25 of potash. Hydrochloric and lactic acids are the only acids which yield energetic, active digestive fluids with pepsin; sulphuric, nitric, and acetic acids yield with pepsin a digestive mixture of only slight power, while phosphoric, oxalic, tartaric, and succinic acids can in no degree replace the lactic or hydrochloric acid in the process of digestion. Fats, when added in certain quantities to the gastric juice, promote the conversion of the protein compounds into peptones." *

* Physiological Chemistry, vol. ii. p. 58.

A knowledge of these chemical facts is of fundamental importance on the part of those who have to treat dyspepsia, a disorder in which we know that there is in some cases an excess of acid in the stomach, whilst in others we have reason to believe that there is a deficiency. We thus obtain a solution of the fact known practically to medical men, that acids, more particularly hydrochloric with nitric, frequently improve the digestive powers; we learn, too, how it is that alkalies often relieve the oppression caused by excess of acid; and we are further led to see clearly that we must necessarily impair or arrest digestion by giving alkalies in such quantity as to reduce the proportion of acid below 1.25 in 100 parts. An acquaintance with such chemical facts must tend therefore to give precision and correctness to our treatment of a disease which so often arises from disorders essentially chemical in their nature.

Digestion of Food in the Stomach. — The food is not all dissolved in the stomach. The gastric juice exerts little or no influence on starch, sugar, or gum, though sugar seems to be absorbed by the blood-vessels of the stomach. Fat also undergoes no change itself, though it has been proved that the presence of a moderate quantity promotes very much the solvent action of the gastric juice on the albuminous kinds of aliment. It is upon the latter, the azotised or albuminous substances which are destined to replace the worn-out tissues of the body, that its action is chiefly exerted. The white of egg, the fibrinous or muscular parts of meat, the curd of milk or cheese, and the gluten or adhesive part of flour (which forms so large a portion of the nutritive part of bread), are the best examples of the albuminous kinds of food. The gastric juice has also a special solvent power on the gelatinous aliments; and when

they have once been dissolved they are so altered by it that they are incapable of again forming a jelly.

It was formerly believed that the only use of the gastric juice was to dissolve these kinds of food, and to convert insoluble and coagulated substances into the corresponding soluble matters fitted for absorption. It has now, however, been ascertained that, by the action of either natural or artificial gastric juice, there are formed thoroughly new substances, which, although they coincide in their chemical composition, and in many of their physical properties, with the substances from which they are derived, essentially differ from them, not only in their ready solubility in water and even in diluted alcohol, but in having now lost the faculty of forming combinations with most metallic salts. The formation of these fluid substances, which have been called peptones, depends solely on the action of the gastric juice, and occurs without the evolution of any gas, and without the production of any secondary substances. Soluble as well as coagulated albumen undergoes a change in digestion; and the properties of the resulting peptone are alike in both instances. It is also worthy of notice that M. Bernard found, in injecting a solution of albumen, made with hydrochloric acid, into the blood, that it speedily passed out by the kidneys, appearing in the urine, whilst after injecting a solution of albumen made with gastric juice no trace of it could be detected in the urine. It would therefore seem, from these facts, that the gastric juice has not only a solvent but also a converting power; the former due to the acid, and the latter to the pepsin ferment.

We have seen that the digestion of mixed kinds of food is not completed in the stomach, that albuminous principles only are entirely dissolved in the stomach, the starchy, saccharine, and oleaginous undergoing very little change, beyond being macerated. As soon, however,

as this partially digested food, or chyme, passes through the pyloric opening into the duodenum, it is subjected to other influences, which complete the digestion, and fit it for absorption by the lacteals and blood-vessels. These influences, which we shall now notice, are the action of the pancreatic juice, the bile, and the secretions from the intestinal mucous membrane and glands.

The *pancreatic juice* is an alkaline fluid resembling the saliva in its appearance and in some of its properties, but it contains a larger proportion of solid matters. It has the same power of converting starch into sugar; but its principal constituent, the ferment to which this property is owing, though it resembles albumen or casein, is not perfectly identical with them, or even with the ptyalin of the saliva. It is very prone to decomposition, and emits an odour of putrefaction after exposure to the atmosphere for a few hours. It is precipitated by acids, but is re-dissolved by alkalies. Its chief office seems to be the conversion of the starchy part of the fluid into sugar; but it serves another equally important office in promoting the absorption of the fatty part of the food. This it does by reducing the fatty matters to the state of an emulsion; and the fat is, in this state of fine division, more readily taken up by the absorbent mouths of the lacteals.

The *bile* serves some important purposes in the digestive process. It neutralises the acidity which the food has acquired from admixture with the gastric juice; and it has an action similar to that of the pancreatic fluid in promoting the absorption of fat. There are also facts which show that the bile has a decided influence in checking the tendency to abnormal fermentive action in the food after it has passed from the stomach into the duodenum and intestines. It is known that when the secretion of bile is arrested, so that none of this

secretion is mixed with the intestinal contents, they are very prone to undergo putrefactive decomposition; and hence we often find that patients labouring under jaundice are troubled with flatulence and with attacks of diarrhœa. It has also been found by experiments on some of the lower animals, that, when the bile ducts are tied so that no bile is allowed to enter the intestines, rapid decomposition takes place after the use of fleshy animal food, causing flatulent distension of the intestines from the evolution of foetid gases. Some have therefore considered that the bile has an antiseptic action, while other physiologists ascribe to it the property of imparting by its own decomposition a definite direction to the metamorphosis of the chyme. Of the other uses of the bile, in promoting the secretion of the intestinal mucous membrane and in exciting the peristaltic action, and thus obviating constipation, or of the purposes it serves as a recrementitious secretion, I shall not now make more particular mention.

The *intestinal juice*, or secretion of the bowels, has a very important influence in completing the digestion of the food. It consists chiefly of the secretion of the mucous membrane, and of that of the glandular follicles, but it is also mixed with the bile, and the pancreatic and the gastric secretions; and it is worthy of remark that it is an alkaline secretion the solvent power of which is not diminished by admixture with bile, which destroys that of the acid gastric juice secreted by the stomach. It has also more the character of a universal solvent; for it has been found that it changes starch into sugar as rapidly as the saliva or the pancreatic fluid, and exerts as powerful a digestive influence on flesh, albumen, and other protein bodies, as the secretion of the stomach itself. In the middle part of the small intestines the contents are alkaline; but they lose this property towards the lower part, and in the cœcum acquire

an acid reaction from a kind of fermentive action, causing the transformation of starch into lactic and butyric acids.

Such are, then, the most important influences, having a reference to fermentive actions, to which the food is, during healthy digestion, subjected in the stomach and the intestinal canal.

CHAP. II.

THE CHEMISTRY OF FERMENTATION.

NATURE OF FERMENTATION. — EFFECT OF THE ATMOSPHERE. — OF TEMPERATURE. — FERMENTIBLE SUBSTANCES. — FERMENTS. — VARIETIES OF FERMENTATION. — SACCHARINE. — VINOUS. — MUCOUS. — LACTIC AND BUTYRIC. — ACETOUS. — BENZOIC AND CASEOUS. — FATTY. — ANTIFERMENTIVE AGENCIES. — SUBSTANCES WHICH CHEMICALLY ARREST FERMENTATION. — EFFECT OF THE YEAST PLANT, THE SARCINA, AND OTHER MICROSCOPIC PLANTS, ON FERMENTIVE ACTIONS.

IN the preceding chapter we have examined the process of digestion in the natural condition, with the view of ascertaining how far fermentive actions are concerned in it; and we have seen how important a part purely chemical actions perform in the solution and preparation of the food for absorption into the blood. Before entering on the practical part of our subject, relating to the disorders in this function which result from abnormal fermentive actions being set up in the stomach and intestinal canal, it is necessary to inquire what is the nature of fermentation, to examine the varieties of it known to the chemist, and likewise to ascertain what agencies promote these chemical actions, or retard or arrest them.

Liebig is the chemist to whom we are most indebted for what knowledge we possess of the various fermentive processes, as well as for the light which has been thrown by his researches on the chemistry of food. He has, undoubtedly, led the way in investigations tending to

prove the dependence of physiological knowledge upon an intimate acquaintance with chemistry ; and many of the clear and simple views of vegetable and animal physiology propounded by him, though at first disputed, have gradually commanded more general assent, and must exert an enduring influence on the progress of physiology. Speaking of the close relation of chemistry to medicine and physiology, he observes: "How differently would the treatment of diseases be conducted if we had perfectly clear notions of the processes of digestion, assimilation, and excretion! Without just views of force, cause, and effect ; without a clear insight into the very essence of natural phenomena ; without a solid physiological and chemical education, is it to be wondered at that men, in other respects rational, should defend the most absurd notions—that the doctrines of Hahnemann should prevail in Germany, and find disciples in all countries?" Again, he remarks, "without a profound study of chemistry and natural philosophy, physiology and medicine will obtain no light to guide them in the solution of their most important problems: that is, in the investigation of the laws of life, the vital processes, and the removal of abnormal states of the organism."

These observations appear particularly applicable to the subject under consideration ; for we have seen that the functions of the stomach are essentially chemical, and that the food is dissolved by a process of a fermentive nature. This, however, has scarcely been taken into account at all by medical men in their treatment of dyspepsia or other diseases ; and yet many of our remedies, almost all of which are introduced through the medium of the stomach, exert more or less influence on fermentive actions, and many must also vary in their effects, according as they are taken whilst digestion is going on, or when the stomach is in a state of repose.

Nature of Fermentation. — The vinous fermentation, which occurs during the formation of wine from the juice of the grape, and of beer from the infusion of malt, and by which the atoms of sugar are split up and converted into alcohol and carbonic acid, is the species with which we are most familiar. In all cases, the presence of two organic matters which occur in both of these fermentable fluids is requisite, in order that fermentation may take place when the fluid is placed in suitable circumstances as respects temperature and exposure to the atmosphere, &c. Sugar, which exists in both fluids, is incapable, when in solution by itself, of spontaneously undergoing any change; but in the juice of the grape there is also an azotised or albuminous substance, which exerts no influence on the sugar so long as it has not been exposed to the air. By exposure to the atmosphere, however, it absorbs oxygen, and a decomposing action analogous to that of putrefaction is set up, and the state of change or motion, in the albuminous matter which acts as a ferment, is communicated to the sugar in contact with it. In the fermentation of beer, the same change takes place in the saccharine matter of the infusion of malt, from the reaction of the azotised or albuminous ferment, gluten. The process is, however, hastened by the addition of yeast, a more perfectly developed and active ferment, in which the yeast plant is already abundantly formed.

The oxygen of the atmosphere is, according to some chemists, the original moving power by which fermentive action is excited. It excites the first changes in the ferment, but is not absorbed during the conversion of sugar into alcohol and carbonic acid. A solution of sugar undergoes no change when exposed to the atmosphere at a temperature suitable for the production of fermentation; but if it be mixed with an albuminous substance, such as white of egg, cheese, or the gluten of

wheat, it passes sooner or later into a state of fermentation. These azotised substances are very prone to undergo putrefaction from the action of the atmospheric oxygen; and when in this state of change or motion, they communicate a similar movement to the different kinds of fermentable substances. The number of substances occurring in nature which, according to Liebig's definition, are truly putrescible, is singularly small; but they are everywhere diffused, and form part of every organised being. Before all other substances, this property of putrescibility belongs to the highly complex matters of the animal and vegetable kingdoms which contain nitrogen and sulphur, such as albumen, fibrin, casein, gelatine, and the like. Urea, sugar, sugar of milk, asparagine, and amygdaline, as well as the various organic acids, undergo, when pure, under circumstances otherwise favourable for fermentation, no perceptible change; but if we cause a putrescible body, such as casein, fibrin, blood, or animal mucus, to enter into putrefaction, and then add to it a solution of sugar, or of sugar of milk, or of urea, &c., these substances pass into fermentation. It would therefore seem that fermentation is only a modification of the putrefactive action, this modification being produced by the controlling action which the fermenting body exerts on the ferment. Liebig says, "We observe, in fact, that when solution of sugar is added to putrescent animal matter, cheese or blood, the beginning of the fermentation is attended by the diminution of the formation of those products which give their offensive smell to putrid animal matters; so that in the course of the process these striking products entirely disappear." Another circumstance, showing the similarity of the two actions, is the fact that the same chemical agents which stop fermentation by combining with the ferments, are most of them also antiseptic, and check putrescence.

The general effect of fermentation is to reduce complex organic substances to simpler compounds. We shall see, in considering the different kinds of fermentation, that temperature has a wonderful influence on the nature of the products, and also that the condition of the ferment has an influence, as well as the kind. "The juice of carrots, beet-root, or onions, which is rich in sugar, when allowed to ferment at ordinary temperature, yields the same products as grape-juice; but at a higher temperature the whole decomposition is changed: there is observed a much less copious evolution of gas, and no alcohol is formed. If we examine the fermented liquor, there is no longer any sugar, but a large quantity of lactic acid, and a body resembling gum arabic, and, as the most remarkable product, a crystallisable substance in composition and properties identical with the chief constituent of manna, namely, mannite; all these are found to have been produced." * Another example of the influence of varying temperature on fermentation is found in its effect on milk. At the ordinary temperature the milk sugar contained in milk passes into lactic acid, and it sours; but at the higher temperature of from 76° to 90° , the curd acquires the properties of common yeast, and two successive transformations take place. The milk sugar first passes into grape sugar by taking up the elements of water, and then, by contact with the casein or curd, which acts as a ferment, it is resolved into alcohol and carbonic acid, and from this alcoholic liquid true spirits may be obtained by distillation. The fermented liquor obtained from mare's milk, which contains much sugar, is called koumiss, and is used by the Tartars as an intoxicating drink.

As regards ferments, they are all, whether of vegetable or animal origin, of an albuminous nature, having,

* Liebig's Familiar Letters on Chemistry, p. 188.

as Liebig observes, the same composition as blood and cheese. One ferment, however, produces a different effect from another; and the same will, with a change in its condition, produce another kind of fermentive action. With different fermentive substances the same ferment is also capable of exciting different kinds of fermenting actions. Gluten is a ferment which has been found to contain three similar but not identical proximate principles. It has been thought that the soluble part is the cause of the weak species of fermentation called the mucous; and each of the proximate principles may have a tendency to excite a different kind of fermentive action. The diastase or gluten of malt altered by germination, which is the appropriate ferment for the conversion of starch into sugar, produces lactic acid fermentation with a solution of sugar; and towards the end of the fermentation, part of the dissolved diastase is precipitated in a further state of alteration as wine ferment, which then brings the rest of the sugar into the state of vinous fermentation.*

The secretion of mucous membranes as well as the substance of them, consisting of gelatinous and albuminous matters, act as ferments; and Gmelin observes that fresh animal membranes, such as the bladder and the lining membrane of the stomach, immersed in water in an open vessel, pass through certain successive stages of decomposition, and accordingly, in the first phase of their decomposition, bring a solution of sugar into the state of lactic acid fermentation; in the second, into mucous fermentation; and in the third, into vinous fermentation. Liebig has also stated, that with a piece of the mucous membrane of the stomach in a certain stage of decomposition, we may render certain animal

* Gmelin.

substances soluble; whilst with the same membranes in other stages of decomposition we may convert starch into sugar, sugar into mannite and mucus, or into alcohol and carbonic acid, and lactic acid into butyric acid, hydrogen, and carbonic acid.

We have noticed the action of casein in causing lactic acid fermentation, and at a higher temperature the butyric. In the almond and some other seeds there is a vegetable casein very closely resembling that of milk, which has likewise the properties of a ferment. Animal and vegetable casein both produce the same fermentive influence on sugar; and if the milk of almonds be added to a solution of grape sugar, it may be made to ferment briskly, and brandy of a peculiar but very fine flavour may be obtained from the fluid by distillation. Vegetable casein differs, however, slightly from animal casein in containing more nitrogen; and it has the power of causing some remarkable transformations of a fermentive nature in amygdaline and some other organic substances, which are not at all affected by animal casein.

There are some substances which, without having any of the properties of ferments, possess, nevertheless, a certain power in promoting or modifying fermentive actions. Thus lime exerts some effect in promoting a kind of fermentation in several of the organic acids. Many of them, though not fermentable by themselves, may be made to undergo fermentation when combined with lime in the form of a salt. Malate of lime ferments with yeast as readily as solution of sugar. At a low temperature pure carbonic acid gas is evolved, and the malate is resolved into succinate, acetate, and carbonate of lime. At a higher temperature hydrogen gas is evolved, and there is produced from the malic acid a large quantity of the butyrate of lime. Lactate of lime yields, in contact with putrid cheese, carbonic acid

and hydrogen gases, butyric acid, and mannite. Tartrate of lime yields carbonic acid, metacetate and acetate of lime.*

The term fermentation was originally applied to the vinous, the form with which we are most familiarly acquainted; but it has of late years been extended to several other chemical changes, and fermentations are now arranged into twelve classes†: 1. The alcoholic; 2. The saccharine; 3. The viscous or mucous; 4. The lactic; 5. The acetic; 6. The gallic; 7. The pectic; 8. The benzoic; 9. The sinapic; 10. The ammoniacal; 11. The putrid; and 12. The fatty.

I need not enter into details connected with each of these classes, as the exact nature of the changes is not yet in every case fully understood by the chemist, and as it may therefore be doubted whether they are all properly arranged as true varieties of fermentation; but I have still to notice a few particulars with reference to the more important of the acknowledged forms of fermentation.

Saccharine Fermentation. — The saccharine form of fermentation is one peculiarly interesting to the practical physician, inasmuch as it occurs in a disordered state of the digestive organs, which is a chief cause of that very intractable disease called diabetes. But though this disease is one arising from disorder more peculiarly of a chemical nature, and much has been written on the subject, it has not as yet been so studied in its chemical aspects as to place the treatment on a certain basis or on correct chemical principles; and the discovery of a chemical agent which might be used as a remedy to effectually arrest the saccharine fermenta-

* Liebig's Familiar Letters, p. 190.

† Ure's Dictionary of Arts and Sciences, art. "Fermentation."

tion in the stomach, in cases of diabetes, is a desideratum. The saccharine fermentation is that by which starch is converted into sugar and gum. It occurs under the influence of several ferments, and in various domestic or chemical processes, as well as spontaneously in many natural processes, such as the germination of seeds and the ripening of fruits, and even during healthy digestion.

If two parts of potato starch are boiled into a paste with twenty parts of water, and mixed with one part of the gluten of flour, the mixture, if kept for eight hours at a temperature of from 122° to 167° , loses its pasty character, and becomes thin, transparent, and sweet, the starch being first converted into gum, and then into sugar. With diastase the same change takes place in one hour, showing the more powerful nature of this ferment. A similar change takes place when the flour of wheat, rye, or of any of the other cereals, is treated in the same way. The starch of the flour absorbs water, there is a new arrangement of its atoms, and it changes first into gum and then into sugar; and this produces the liquefaction of the dough in the baking of bread, from the action of the gluten on the starch. It is supposed that the formation of sugar from starch is due to a change of the same nature as that which occurs when it is boiled with sulphuric acid; but the whole theory of the change has not yet been fully developed by chemists. Diastase, which is the most energetic ferment for this kind of fermentation, may be obtained from malt in a perfectly pure state by a chemical process; and it is a white solid. Its power is so great that one part is sufficient to cause the transformation of 2000 parts of dry starch. In autumn starch is stored up in many seeds and plants, and in spring undergoes this transformation into sugar under the influence of germination and the renewed vital activity of the plant; and the

sugar which in spring is obtained from the ascending juice of the maple tree is in autumn deposited in the woody fibre in the form of starch.

The action of animal substances in producing the saccharine fermentation has been already referred to; and we have seen that the salivary diastase and the pancreatic juice have this power.

Vinous Fermentation.—This kind of fermentation, by which sugar in solution is converted, under the influence of the common yeast ferment, into alcohol and carbonic acid, is too well known to require any lengthened notice here. It takes place most actively when one part of sugar is dissolved in ten parts of water and the solution is kept at a temperature of from 68° to 77° : one and a half per cent of yeast is also necessary if the fluid does not contain albuminous matter capable of acting as a ferment. Yeast is found, when examined microscopically, to consist of oval nucleated cells or globules, which have been called the *Torula cerevisiæ*, or yeast plant; and the growth of these has been regarded by some as the active agency by which the vinous fermentation is induced. Examined chemically, the essentially operative constituent of the yeast is found to be a peculiar azotised matter which may be obtained in a separate state. It is insoluble in cold water and alcohol, but dissolves in weak alkaline solutions, and even in lime water. When diffused through water, it assumes a homogeneous aspect, as if it were really dissolved; but when the mixture is heated, it coagulates and loses some of its properties. Acids precipitate it, and also earthy and metallic salts, which likewise combine with it and throw it down. Wine yeast and beer yeast, according to Liebig, are far richer in oxygen than the substances from which they are derived; and the presence of air is therefore favourable to the process, by affording a

constant supply of oxygen whilst the fermentation is going on.

Viscous or Mucous Fermentation. — This is a kind of weak fermentation which takes place in diluted solutions of sugar when there is deficiency of good yeast. A small quantity of hydrogen gas, as well as carbonic acid, is disengaged; and a kind of gum or slime is formed, which is the cause of the ropiness of some wines. It would seem that it is the soluble part of gluten that causes this kind of fermentation; and it is excited by boiling yeast, and adding sugar to the liquid after filtering it, so as to separate the coagulated part. The albuminous ferment of the juice of the grape is of two kinds: the one is soluble through the influence of the alcohol and tartaric acid, and this produces the viscous fermentation; the other is insoluble, and it produces the vinous fermentation. Alum and tannin stop the viscous fermentation by precipitating the ferment; and it is worthy of notice that the ropiness caused by this fermentation never occurs in red wines, owing to the tannin which they contain. A ferment of globular form, like that of yeast, is formed during the viscous fermentation, which is capable of causing the same fermentation in any saccharine solution to which it is added, provided the temperature be suitable. This species of fermentation, unlike the vinous, goes on as well in close as in open vessels.

Lactic Fermentation. — This is the kind of acid fermentation which causes the coagulation of milk. Milk is an alkaline fluid, and the curd is kept in solution by the presence of free alkalies and alkaline phosphates; and when any acid is added, the curd or cheese separates in an insoluble state. Rennet produces the same effect, by acting as a ferment and causing the sugar of milk to

undergo the lactic acid fermentation. One atom of sugar of milk is converted into two atoms of lactic acid without the absorption of oxygen or evolution of any gas; and the curd itself having the property of acting as a ferment, it is from this same fermentive action, occurring more slowly, that milk always becomes sour when left to itself, and coagulates after a certain time. Many azotised organic matters are capable of causing this fermentation, after being changed by contact with the air. Diastase and casein produce it as well as animal membranes, but they must not be putrescent. Cane sugar, grape sugar, dextrine, and sugar of milk are all capable of undergoing this fermentation at a temperature of from 67° to 86° . It is said that all the agents which stop the alcoholic, stop also the lactic fermentation, whilst diastase and casein are its two best exciters.*

Butyric Acid Fermentation. — It has been already observed that, at a temperature of from 76° to 86° , milk becomes sour from lactic fermentation. At a higher temperature, from 90° to 100° , the sugar of milk, or even common sugar in solution, with the addition of decomposing cheese, which acts as a ferment, undergo a different kind of fermentation, which is attended with an evolution of hydrogen and carbonic acid gases, and the formation of an oily acid, the butyric, instead of the lactic. It is not improbable, however, that as lactate of lime yields butyric acid in contact with putrid cheese, the lactic fermentation may precede and accompany the butyric, just as we know that the acetous often accompanies and succeeds the vinous.

The frequent occurrence of these two closely allied kinds of fermentation during digestion, causing acidity

* Ure's Dictionary.

and heartburn, renders them peculiarly interesting to medical men in a practical point of view.

Acetous Fermentation. — In this species of acid fermentation, alcohol is oxidised and converted into vinegar; and the requisite conditions are a vinous or alcoholic fluid containing some yeast ferment, and exposed to the action of atmospheric oxygen at a temperature of 66° . Common yeast acts most powerfully as a ferment when it already contains vinegar; but it does not seem to be essential for the production of vinegar, which may be formed from alcohol by means of finely-divided platinum, and other modes, by which the number of points of contact with the oxygen of the atmosphere is multiplied. The acetous fermentation may go on along with the vinous in the same liquor when sugar is present as well as alcohol. Sugar may also be converted into vinegar without any previous vinous fermentation, by means of a ferment obtained by precipitating with vinegar the albuminous matter of potato juice. There are some other substances besides sugar which directly ferment into vinegar, such as the mucilage of plants, gum, and starch paste.

Benzoic and Caseous Fermentations. — We have already seen that animal casein, or cheese, may be made to produce several kinds of fermentation; but the vegetable casein of the almond has the additional power of causing some very remarkable changes of a fermentive nature in certain organic substances. The bitter almond contains besides casein a substance called amygdaline, which does not exist in the sweet almond, and which may be extracted in a pure state by means of alcohol. In the dry condition, the vegetable casein in the bitter almond produces no action on the amygdaline; but when the amygdaline, which is a white

crystalline substance, is dissolved by means of water, the casein causes a fermentation by which the amygdaline is resolved into sugar, prussic acid, and volatile oil of bitter almonds. The vegetable casein is a true albuminous ferment, which at a temperature above 140° is coagulated, like the white of an egg, and its fermentive power destroyed. It produces similar decomposing effects on salicine and other vegetable principles, which are not affected by animal casein; and, as we know that almonds produce indigestion, and are peculiarly noxious to some individuals, these fermentive actions of vegetable casein are peculiarly interesting in their dietetic and medical aspects.

Cheese itself appears to undergo a peculiar kind of fermentive change by keeping, which we shall have occasion to notice more fully when we examine its properties as an article of food. Cheese contains the phosphate of lime, and part of the phosphate of soda, of the milk, and the fresh curd is not soluble; but by being kept till mature, the casein returns to a soluble state, this depending on the decomposition of the phosphate of lime by the margaric acid produced by a chemical change in the butter. Margarate of lime is thus formed, whilst the phosphoric acid combines with the casein, producing a compound soluble in water.

Fatty Fermentation.—Fat and oils are capable of undergoing a fermentation called the fatty. The circumstances necessary for it are like those of other fermentations, viz., the co-operation of an albuminous ferment with water, and a temperature from 60° to 86° . The matter then becomes warm and assumes the character of rancidity, one of the oily acids, such as the stearic or margaric, being generated; and it is a slow change of this nature which appears to take place in

the butter of cheese when it has been kept for a length of time.

Antifermentive Agencies. — The presence of atmospheric air, it has been observed, is necessary in order to cause the beginning of many kinds of fermentation; and it accelerates most of them. It appears to act by furnishing oxygen; but there is also reason to believe that it supplies the germs of microscopic plants. A boiling temperature puts a complete stop to every kind of fermentive action. The ferments, being all of a nature more or less nearly allied to albumen, are coagulated at a boiling temperature; and it is believed that the change thus produced on the ferments is the cause of the complete stoppage of the fermentive action, which is not renewed so long as the atmosphere is excluded. On this principle it is that meat may be preserved from putrefaction for years, by being sealed up at a boiling temperature so as to exclude the air perfectly. On the other hand, it has been thought by some scientific observers, and not without some apparent foundation, that boiling arrests fermentation by destroying the germs of microscopic plants and animals. To this point, however, we shall have occasion to revert. Dryness and a freezing temperature are other agencies which oppose fermentive actions.

There are many chemical substances which have the power of checking or completely arresting fermentive actions; and as a considerable number of them are much in use as medicines, it must be obvious that it is a matter of some importance that medical men should be aware of their power of checking those actions which, we have seen, perform a part both in healthy digestion, and in producing abnormal digestion or dyspepsia. It is, however, to be regretted that this

subject has not yet received the close examination from scientific and practical chemists which it merits, and that so little is yet accurately known of how most chemical agents affect the various fermentive actions. In dealing with this subject, I shall first state what is at present known in reference to it, and afterwards advert to a few facts which I have ascertained from my own researches.

Sulphurous acid and its salts the sulphites have been regarded as amongst the most powerful agents in stopping vinous and other fermentive actions, and they are also powerfully antiseptic. The vapour of burning sulphur is not only a disinfecting agent, but it is also diffused through casks to prevent acid fermentation in cider and other kinds of fermented liquors; and it has been supposed that it acts by combining with oxygen and abstracting it from the ferment. The bisulphite of lime is a soluble salt which is a very important chemical agent in the manufacture of sugar from beet root, being used to prevent fermentation, and the formation of acid, in the sweet liquor obtained from this root. Sulphuric acid, and also the other mineral acids, have considerable power in opposing fermentation. Alcohol and wood spirit arrest fermentation and destroy the active power of yeast; the former, it has been said, acts by abstracting water from the ferment. We have already seen that the alkalies act chemically on some ferments, dissolving yeast; and they, as well as nitre and common salt, have antifermentive powers. Many metallic salts coagulate albumen, and most of them check fermentation, more especially the salts of mercury and copper. Tannin and alum, by coagulating the ferment of mucous fermentation, arrest this kind. Chlorine and chromate of potash oppose fermentation; and it has been stated that arsenious acid and corrosive sublimate kill fungi and infusoria, but that nux vomica destroys

the latter only. The oil of turpentine, and the essential oils generally, oppose fermentation; but those more particularly which contain sulphur have decided anti-fermentive properties, as, for instance, the essential oils of mustard and horseradish. Creosote coagulates albumen, and is a powerful antifermentive and antiseptic agent. Pyroligneous acid and most empyreumatic substances seem also to have the same properties; and hence wood which has been charred is in a great measure preserved from decay. The antiseptic properties of charcoal are also well known; and in the quick vinegar-making process, by which the alcoholic vapour is oxygenated by being made to trickle through shavings of wood and twigs, any charring of these prevents the formation of the acid. The antiseptic agents which act most powerfully in preserving wood from decay, are corrosive sublimate and the sulphate and the chloride of copper.

With the view of testing the action of some of these antifermentive chemical substances, I have made a few experiments on the effects of these and some others, used medicinally, on the vinous and on the lactic fermentations. On the vinous I have tried the effect of the following agents, viz., sulphurous acid, sulphite of soda, prussic acid, sulpho-cyanide of potassium, sulphuric, hydrochloric, and arsenious acids, common salt, chloride of lime, solution of chlorinated soda, carbonate of soda, lime water, alum, bichloride of mercury, chloride of zinc, sulphate of copper, sulphate of iron, nitrate of silver, trisnitrate of bismuth, chromate of potass, tannin, gallic acid, mustard, horseradish, garlic, assafetida, oil of turpentine, opium, strychnine, alcohol, wood spirit, creosote, and charcoal. Some of these agents completely put a stop to all fermentive action; others appeared to check it in a slight degree; and one or two seemed to increase it, more particularly alum. This

sult also rendered the barm of lighter colour ; and hence its use by bakers to make the bread more spongy and of lighter colour, in doing which I doubt if it has the deleterious effects so generally attributed to it, as alum is not itself deleterious, and bakers' bread is usually the lightest and most easily digested.

The substances which arrested the fermentive action in the most decided manner were, the bichloride of mercury, nitrate of silver, sulphate of copper, chromate of potass, carbonate of soda, mustard, horseradish, wood spirit, prussic acid, and creosote. These seemed to have the power of entirely destroying all fermentive action. Turpentine, assafetida, and chloride of lime, weakened it very much, but without so completely destroying it. Sulphurous acid and the sulphite of soda appeared to be less powerful antifermentive agents than those just mentioned ; and the sulphuric and hydrochloric acids rendered the fermenting fluid clearer, without decidedly lessening the fermentive action except when added in sufficient quantity to render the fluid decidedly acid to the taste. Tannin caused the precipitation of the ferment, and the absence of any head, but without arresting the fermentation ; and gallic acid, on the other hand, caused an abundant dark-coloured head. No very decided effect seemed to be produced by arsenious acid, chloride of lime, sulphate of iron, charcoal, strychnine, or opium. Garlic, the strong smell of which is due to an oil containing sulphur, did not weaken the fermentive action, as has been generally supposed, but, on the contrary, seemed rather to increase it.

The effects of chemical agents on the lactic fermentation are not so readily judged of as those which are produced on the vinous. With the view, however, of testing the effects of some of the same agents on this kind of fermentation, I placed a saccharine solution, containing decomposing cheese, at a suitable tempera-

ture, with the following chemical substances, in separate vessels, viz., with bichloride of mercury, sulphite of copper, mustard, creosote, wood spirit, sulphate of soda, sulpho-cyanide of potassium, sulphate of iron, common salt, alum, tannin, arsenious acid, and charcoal powder. As the lactic fermentation advanced, the fluid lost the disagreeable odour of decomposing cheese; but that in the vessels containing the bichloride of mercury and sulphate of copper retained the original odour without the development of the slightest acid reaction, showing that these agents arrest the lactic fermentation as completely as the vinous. There was scarcely any appearance of change or formation of acid in those vessels containing mustard and creosote, and the development of acid was feeble in those with sulphite of soda and sulphate of iron, which appeared to have more power in checking lactic than vinous fermentation. None of the other agents, except the wood spirit, seemed to have any power in checking this species of fermentive action.

We would notice the fact proved by these experiments, that whilst three of the most powerful agents in arresting both of these two kinds of fermentive actions, viz., bichloride of mercury, sulphate of copper, and creosote, are likewise most powerfully antiseptic, there are others, equally powerful in arresting putrefaction, which exert no well marked influence in preventing these fermentive actions. Arsenious acid, for example, stops the putrefaction of animal substances, but has no marked influence on either kind of fermentation; and we have seen that the chloride of zinc, which is used as a disinfecting agent, has no very decided effect in checking vinous fermentation.

GROWTH OF FUNGI.

We have already seen that the presence of atmospheric air is essential for the commencement of fermentation; and there is reason to believe that it acts not merely by affording oxygen, but also, in some instances at least, by furnishing the spores or germs of microscopic plants. I refrain, in a work the object of which is entirely of a practical character, from discussing the chemical theories of fermentation; but I must not omit to observe that there is a difference of opinion among the most eminent chemical philosophers as to how far fermentive actions are influenced by the growth of microscopic fungi, such as the yeast plant. Liebig ridicules the idea of it being possible that fermentation should arise from the vital manifestations of plants, or putrefaction from the development of animalculæ. He appears to regard the generation of the yeast plant as a mere concomitant of vinous fermentation; and he remarks with respect to the theory which regards the putrefaction of animal matters as produced by microscopic animalculæ, that it may be compared with the idea entertained by a child, who explains the rapid fall and current of the Rhine through the numerous Rhine mills at Mayence, by supposing that the mill-wheels, by their force, urge the water downwards towards Bingen. Though there are many facts which tend to show that fermentation is essentially a chemical process, we must not be so led away by Liebig's reasoning as to overlook some others which tend to show that the generation of fungous plants exercises a very important influence in hastening at least, if not in producing, fermentive action. We know that when a fluid capable of spontaneously undergoing vinous fermentation is set aside for that purpose, it does not at once ferment unless yeast, in which the plant is already developed, be added, and

that during the fermentation the quantity of yeast cells is increased when the fluid contains sufficient albuminous matter. It is a singular fact, also, that the power which yeast has of exciting vinous fermentation is destroyed by rubbing it in a mortar till all the cells are broken down, but it still retains the power of exciting lactic acid fermentation.

The strongest facts, however, tending to prove the influence of fungi in producing fermentive actions are the experimental researches of Schulze, Cagniard de la Tour, and Schwann, referred to by Dr. Ure*, who observes that they appear to show that the vinous fermentation and the putrefaction of animal matters, processes which have been hitherto considered as belonging entirely to the domain of chemical affinity, are essentially the result of an organic development of living beings. It would seem that the air contains the germs of microscopic plants and animals; and when they find a proper soil for their development, such as nitrogenous bodies, they produce fungi and infusoria, which induce fermentation and other changes. In the experiments alluded to it was found that decoctions of meat could be kept for six weeks at a temperature of from $63\frac{1}{2}^{\circ}$ to 77° without any appearance of putrefaction or mouldiness, by first heating to the temperature of boiling water, and afterwards admitting no air except what had passed through a tube, heated so as to destroy the germs of plants and animals. It was also found that when two solutions of sugar mixed with yeast were boiled, and were afterwards exposed to a current of atmospheric air heated in a similar manner, they did not ferment; whereas two other solutions which were treated in the same way, except that the air admitted had not been

* Dictionary of Arts and Sciences.

heated so as to destroy the germs, underwent fermentation.

We cannot, therefore, I think, doubt that while fermentation is essentially a chemical process, living fungi also exercise an important influence on some kinds at least, such as the vinous; and they would appear also to produce an effect on the course and products of the decomposition.

There are several microscopic plants or fungi which have been observed in connection with actions of fermentive nature, and the following require a brief notice here, viz., the *torula cerevisiæ*, or yeast plant, called by Robin the *cryptococcus cerevisiæ*, the *cryptococcus guttulatus*, the *penicillum glaucum*, and the *sarcina ventriculi*.

It is well known that the common yeast plant consists of a minute oval cell with a nucleus, and that the cells or plants multiply by the formation of smaller cells, which appear to form on the sides of the larger ones, and thus arrange themselves in bead-like rows. These cells are found in barm, and a particle of German yeast examined with the microscope is found to consist of nothing but a multitude of these simple cells. They are found not only in beer, but also in many cases in the fermenting matters ejected from the stomach, and they are spontaneously generated in the saccharine urine of diabetic patients. Robin* describes another kind of fungus, the *cryptococcus guttulatus*, which is double the size of the former, and more elongated. It has been found in the mucus of the intestines of some of the lower animals, such as the rabbit, and in some of the herbivorous animals when the transformation of starch into sugar is going forward. He thinks that it has no action on the animal.

* Histoire Naturelle des Végétaux Parasites qui croissent sur l'homme et sur les animaux vivants. Par Charles Robin.

The *penicillum glaucum* is another of those fungous plants which originates in vesicles or cells, from which branches shoot out till a complete network of fibres is formed. It is generated spontaneously in any albuminous fluid which is acid — in an acidulated solution of white of egg, or in the serum of the blood, or in pus rendered acid. It is also formed during the fermentation of beer, and is found in the top barm. Andral* and Gavarret have proved very clearly that it has no influence in causing the vinous fermentation, and that it forms during the fermentation of beer or similar fluids simply because they contain vegetable albumen, and have an acid reaction, presenting, therefore, all the conditions requisite for the spontaneous generation of this fungus. Under the name of vinegar plant is known a remarkable vegetable production formed in fluids rich in sugar, when undergoing fermentation at ordinary temperatures and conversion into vinegar. It forms a tough gelatinous mass floating on the surface of the liquid, and Dr. Griffiths† and Mr. Henfrey are of opinion that it consists of the mycelium of the *penicillum glaucum*.

In the vinegar of wine, malt, or that in which organic matter has been infused, there appears a peculiar mould plant, belonging to the genus *mycoderma*. It does not, like the yeast plant, however, promote acetous fermentation, but decomposes the acid, and leaves eventually nothing but water.

The *sarcina ventriculi* is another of these microscopic fungi, which is peculiarly interesting to medical men, as it is generated in the human stomach, and has rarely been found in any other organ or fluid of the body. It was discovered in 1842 by Professor Goodsir, who

* Annales de Chimie et de Physique, 3 serie, t. 8.

† The Micrographical Dictionary

has given a very minute description of it, and compared its appearance to that of a bale of wool, and hence the name of sarcina. It consists of a square plate, or rather of a square solid bale, divided into four by two lines crossing each other at right angles. Each individual consists, therefore, of four cells, and they multiply by each of these four squares or cells, again subdividing into four secondary cells, and thus we often find many squares or packets grouped together. Perfect individuals vary from 800 to 1000 of an inch linear along each of their sides, and they have a slightly yellow or brown colour. Professor Goodsir considers the sarcina most nearly allied to the genus gonium, among the volvocinæ, and, having fully discussed the question of its animal or vegetable nature, he came to the conclusion that it is a vegetable.

For a detailed account of the natural history of the sarcina I would refer to Robin's work. Its influence in producing fermentive action has been denied by several medical observers; but in the next chapter we shall see that the sarcina and the torula, as well as the penicillum glaucum, are generated in the stomach, and that they probably have an active influence on the fermentive disorders which occur in this organ.

CHAP. III.

FERMENTIVE DISORDER, WITH VOMITING OF SARCINA AND YEAST PLANT.

FERMENTATION WITH SARCINA THE MOST ACTIVE SPECIES PRODUCED IN THE STOMACH.—CASE IN WHICH PROFESSOR GOODSIR DISCOVERED THIS MICROSCOPIC PLANT IN THE VOMITED MATTER.—CASES TREATED BY THE AUTHOR. — OTHER CASES. — INFLUENCE OF SARCINA ON FERMENTATION. — RELATIONS OF SARCINA TO MORBID STATES OF THE STOMACH. — ARRANGEMENT OF RECORDED CASES IN FOUR SERIES. — ANALYSIS OF THE SYMPTOMS IN THIS FERMENTIVE DISORDER. — TREATMENT. — DIETETIC. — ANTIFERMENTIVE REMEDIES. — THOSE NECESSARY FOR RELIEF OF ORGANIC AFFECTIONS OF THE STOMACH.

HAVING shown that healthy digestion is owing to a kind of fermentive action, and having also brought under consideration the chief facts known to the chemist, which appeared to admit of application in the management of digestion, and the treatment of those disordered states which arise from unnatural fermentation, we are now in a position to enter on the practical part of our subject, and to examine those unnatural fermentive actions which produce so many forms of dyspepsia.

There is a kind of fermentation which occurs in the stomach in many of those cases where the sarcina ventriculi has been ejected from it by vomiting, which is of as well marked and active a character as the vinous or any of the other kinds of fermentation which the chemist is able to produce in his laboratory; and to this, therefore, we shall first direct attention. It is also accompanied with a train of such well marked symptoms that

it seems strange it should not, until a recent period, have been discovered, and separated from other forms of dyspeptic disorder. This appears still more remarkable when we consider that it has long been well known that unnatural fermentation is of not unfrequent occurrence among some of the ruminating animals. The fermentation, which is said to be the acetous, is apt to occur after they have eaten largely of fresh clover, and the gas disengaged not unfrequently distends the stomach to such an extent, owing to the form of it preventing the escape of the gas, that the stomach is ruptured, and the death of the animal produced. I am told, too, that in cart-horses that have been made to work soon after being fed on steamed hay, acid fermentation is very common, causing great distension, and sometimes even rupturing the diaphragm. The best remedy for it is a drachm of the chloride of lime, which no doubt acts as an antifermentive agent; but the lime must also neutralise any acid formed, while the chlorine relieves the distension by combining with hydrogen and its gaseous compounds. In man, however, the construction of the stomach is so simple, that any gas generated escapes readily, and though the flatulent distension from fermentation is often the cause of great inconvenience, and even of alarming symptoms, I am not aware of it having caused fatal effects in any case, except one where the stomach was twisted from its natural position in a peculiar way, so as to prevent the escape of accumulated air; the case was a very remarkable one, which occurred at the Liverpool Northern Hospital in a sailor 20 years of age, who was under the care of Dr. James Carson*, at that time my colleague. After death, the peritoneum was found distended with air, which had escaped through

* See an account of this case in Report of the Liverpool Pathological Society. Edin. Med. and Surg. Journ. No. 168.

a rupture in the stomach, and an acid fermenting fluid was found in this organ.

Since the discovery of the singular microscopic growth called the sarcina ventriculi, the attention of medical men has been more particularly directed to the form of fermentive disorder in which this fungus occurs, either alone or in conjunction with the yeast plant; and I shall first notice this, which constitutes the best marked form of fermentive disorder.

The well marked form of fermentive disorder in which we meet with the sarcina is not a common disease; and though a very harassing one, it is probably still in many instances overlooked, or its true nature not fully recognised by some medical men. It occasions, however, a train of prominent and urgent symptoms, which cannot fail to arrest the attention of those who have seen a single case and appreciated its exact nature. The prominent symptoms are vomitings, occurring at longer or shorter intervals, preceded by severe pain at the stomach, and flatulent distension, the ejected matters being generally very large in quantity, highly acid, containing numerous bundles of the microscopic plant, and having the smell and frothy appearance of common yeast. The diagnosis of the disease is of importance, as it indicates an obstructed condition of the pyloric orifice of the stomach, and the presence of sarcina serves also in some measure as a guide to us in the selection of remedies.

The sarcina ventriculi was discovered by Professor Goodsir in a severe and obstinate case of dyspeptic vomiting, of which he has published an interesting account.* The following is condensed from it:—

“Mr. —, aged 19, consulted me about a stomach complaint, under which he had been labouring for four

* Edin. Med. and Surg. Journal, vol. lvii.

months, and which had, more or less, resisted every attempt made for its removal. He informed me that he considered it to be water-brash; that it attacked him on awakening in the morning with a feeling of distension of the stomach; that, without any effort of vomiting, a quantity of fluid, varying in volume from two-thirds to a whole wash-hand basinful, passed up from his stomach; that after this he was quite relieved, and experienced no further inconvenience till the evening of the same day, when, without decided distension, sounds as of a fluid boiling or bubbling, and proceeding from the region of the stomach, were perceptible to himself and to those around him; that he slept well enough, but was generally attacked in the usual manner next morning. Such, he observes, was my patient's own account of his case.

"His tongue and pulse were natural, the bowels regular, the appetite was not affected, and no tumour could be detected in the epigastrium. He was thin, but had a good complexion; and his flesh was firm.

"On examining the ejected fluid, I was struck with the truth of what had been stated to me,—that it smelt like fermenting worts, with a faint acid odour. It appeared, after having stood for a few hours, moderately transparent, and of a light brown colour. It had deposited in the bottom of the basin a quantity of a ropy matter of a granular appearance; and on the surface was a mass of froth like the head of a pot of porter." This fermenting appearance led him to examine the fluid with the microscope, in the expectation that he might find the yeast plant, instead of which he discovered the sarcina. "What was my astonishment, then, to find in the first drop I examined, not the vegetables I was led to expect, but numerous individuals of a form with allies of which the zoologist is familiar." The patient had taken prussic acid with some benefit,

but he now determined to give creosote, in the belief that it might stop the ejection of the fluid, and prevent the fermentation. This it had the effect of doing; and though the complaint was not entirely removed at the time the case was published, there was good ground to expect that eventually it would entirely disappear.

The three following are well marked cases of vomiting of fermenting matter with *sarcinæ* which have come under my own observation:—

R. B., a farm labourer, aged 30, was admitted into the Royal Infirmary, under my care, on the 3rd of May, 1855, having come from Cumberland in the hope of obtaining some relief from severe attacks of pain at the stomach, and frequent vomiting. He stated that for three years he had been troubled with indigestion, acidity, pain at the stomach, and vomiting. At first the vomiting came on only at intervals of a week or ten days, but it had gradually increased in frequency and severity. Eighteen months previous to admission he went to work at a neighbouring farm, where he got pork and other indigestible food for dinner, which aggravated his dyspeptic symptoms very greatly. From that time he got gradually worse, though he was able to continue his work until Christmas. Since then the attacks of vomiting had become very frequent, usually recurring every day or every second day, and almost always in the evening or at night. He had severe burning pain at the stomach, which extended through to the back and the shoulders, and he had often felt a peculiar movement at the stomach, which had made him think that there was something alive in it. The vomited matters were always very acid and frothy, and it had appeared to him that he frequently ejected a much larger quantity than he had eaten and drunk. It also seemed to him that he could never get rid of the entire contents of the stomach, and that some

acid matter always remained. The tongue was clean, but rather red and smooth. The bowels had been generally regular, but sometimes he had been purged. He was very pale, emaciated, and weak, and he had considerable œdema of the ankles. The nails had the clubbed appearance so common in phthisis, but he had no cough previous to admission, and there were no physical signs of tubercular disease of the lungs. Opium, bismuth, and hydrocyanic acid were at first tried, but they did not afford the slightest relief. On the 23rd of May it was observed that the matter he had vomited was in a state of active fermentation, and on examination with the microscope it was found to contain abundance of sarcinæ. I then ordered scruple doses of the sulphite of soda dissolved in water to be taken every four hours. The effect of this remedy, the power of which depends on its antifermentive properties, was prompt and decided in affording the patient relief from his most urgent symptoms. Two days after I found him much better, and the countenance had a less anxious expression. He had not vomited since taking the sulphite of soda, but he had still some pain at the stomach.

On the 29th he was free from pain, and the vomiting had not returned. On the 31st he looked better and felt stronger; his appetite had improved, and he was free from pain and vomiting.

With the view of improving the tone of the stomach, the sulphite of soda was now given in infusion of gentian, instead of water, three times a day. His diet consisted of bread and milk night and morning, and chop, with rice pudding, for dinner.

On the 2nd of June I found that he had vomited the preceding night, but the vomited matter was not in a state of fermentation, and did not contain sarcinæ. He had felt more pain since taking the sulphite of soda

in the infusion of gentian, and he was therefore ordered to have it again in solution in water.

On the 4th I found that he had again vomited the previous evening, and that the vomited matter had a greyish frothy appearance, with a tinge of green. It was acid, fermenting, and a microscopic examination showed that it contained sarcinæ with oil and starch globules. I found that by mistake the sulphite of soda had been given in the dose of fifteen grains, and only three times a day instead of every four hours. He was ordered to take scruple doses every four hours, as the return of the sarcinæ appeared to be caused by the diminished quantity and frequency in which the sulphite had been taken; and, as he complained of weakness, two eggs were added to his other diet.

Though the fermentation and the generation of sarcinæ were thus effectually checked by the sulphite of soda, the pain, which had been at first so completely relieved, returned and harassed him very much, preventing sleep. A pill containing two minims of creosote was therefore given thrice a day, with the view of relieving it, but it failed in doing so; and as he thought that the air of the hospital did not agree with him so well as the country, he became anxious to return home, and on the 8th of June he was discharged at his own request.

Remarks. — The sulphite of soda used in this case is a remedy which was originally tried by Dr. Jenner, at the suggestion of Professor Graham, in a case which will be subsequently noticed. Though it relieved the more urgent symptoms here, those dependent on the fermentation and the generation of the sarcinæ, the success of the remedy was only partial, the pain continuing; from which we may infer that there was probably ulceration or some other organic mischief. The long duration of the disease would, however, lead us to think that it might have originated from functional disorder, and

that any ulceration that might exist was probably not of malignant or cancerous nature.

In the next case vomiting without any pain was the most prominent symptom, and it was so constant, that, as the bowels were not freely opened till a short time before death, it was thought there might have been some intestinal obstruction. The examination after death, however, revealed the existence of cancerous disease partially obstructing the pyloric orifice of the stomach.

W.O., a labourer employed in an iron foundry, 45 years of age, pale, sallow, and rather emaciated, was admitted into the Royal Infirmary, under my care, on the 23rd of September, 1855. He had frequent vomiting, and the bowels were confined. He stated that he had been at work until five weeks previous, when the bowels became costive, and he lost his appetite. There had been much difficulty in moving the bowels by medicine, and injections had also been used, which had caused black motions like pitch. A pill with aloes and hyoscyamus was ordered to be taken every four hours.

On the 22d the vomiting had been very frequent, and no action had been produced on the bowels by the pills. The vomited matter was of dark colour, frothy, and smelt of yeast. It was acid, and on examination with the microscope an abundance of *sarcinae* was discovered. There was no pain at the stomach, but the epigastrium was retracted, and there was a slight feeling of hardness to the left of the median line. The tongue was slightly furred. Scruple doses of the sulphite of soda were now ordered to be taken every four hours, and an enema of castor oil and turpentine was given.

On the 24th he still vomited quite as frequently, but the matter ejected was less frothy, and seemed less abundant, and it no longer contained any *sarcinae*. A black motion was produced by the injection; but as the

pills did not seem to act on the upper part of the intestinal canal, and the vomiting continued very urgent, an examination was made to discover any hernia or intestinal obstruction that might exist: but none was found. Ten grains of calomel, with one and a half of opium, though retained for more than two hours, failed to act upon the bowels, and hydrocyanic acid with soda had no effect in abating the incessant vomiting. On the 29th of September he had the bowels freely opened, after taking a large dose of calomel with opium; the sickness did not, however, stop, and he died the same evening.

On examination there was found to be scirrhus disease of the pylorus. The disease was not, however, extensive, and there was no ulceration. The opening, though contracted, still admitted of the food passing out of the stomach.

Mrs. B., aged 47, a thin, pale, delicate-looking woman, was admitted into the Royal Infirmary on the 8th of November, 1855. Her stomach had been weak, and she had suffered more or less from dyspepsia for five years, but during the previous eight months she had been much worse, having had frequent attacks of vomiting, occurring sometimes twice or thrice in the day. She had occasionally before that period had attacks at intervals of a month or longer. She noticed that since March the matter vomited boiled up like barm, and was always very acid. She had burning pain at the stomach, and great distension before vomiting, which always relieved these symptoms. Three months before admission she vomited blood, and on several occasions subsequently. The skin was cool, the pulse ninety-two, and there was no thirst. The tongue was clean and natural. The appetite pretty good, but kept in check by the pain induced by food. The bowels were confined, and the motions dark in colour. The epigastrium was several times examined, and it was

found full and distended after food, with a tympanitic sound, on percussion, extending much beyond the usual limits of the stomach. At other times there was no distension, and tenderness and some hardness could be distinctly felt on pressing over the situation of the pylorus.

She remained in the Infirmary nearly twelve weeks, during which time the diet was carefully regulated and a variety of remedies used, the effects of which we shall notice as briefly as possible. On admission, a mixture containing carbonate of potass and prussic acid was prescribed, which relieved her so much that the vomiting ceased for three days. On the 12th the matter vomited the previous evening was examined. It had a white appearance from the milk she had been taking, and on the surface there were a few bubbles as if from fermentation. It was acid, and had the smell of yeast. A microscopic examination showed the presence of *sarcinæ*, and a great abundance of the yeast plant. The *sarcinæ* were found chiefly in the mucus, the quantity of which was considerable. The effect of tannin was first tried, and four grains, with the same quantity of hyoscyamus, were given in the form of pills every four hours from the 12th to the 15th of November. No benefit, however, resulted from it, and the vomited matter continued to have the smell and appearance of yeast, with *sarcinæ* and abundance of *torulæ*.

From the 15th to the 20th she took mustard, which was given in the dose of five grains, and afterwards ten grains, suspended in glycerine every fourth hour. This appeared to have some effect in lessening the vomiting and the fermenting appearance of the matter ejected; but as there was reason to believe, from the fact of the patient having vomited blood on several occasions before admission, that there might be ulceration of the stomach, I was unwilling to push the use of such an irritating

remedy to its full extent, and on the 20th I suspended it, as there were still *sarcinæ* and *torulæ*, and gave two minims of creosote instead. No good resulted from the creosote, and on the 23rd I therefore prescribed the sulphite of soda, in scruple doses thrice a day, which has been so often found to afford relief in this class of cases. The vomiting and pain were at first relieved by it, but only for a very short time. On the 26th she was worse: the *sarcinæ* and *torulæ* were still present in the vomited matter, she was very weak, and the pain was more severe. She was ordered to take, in addition to the sulphite of soda, a pill night and morning containing one grain of opium. A solution of sesquicarbonate of soda containing half an ounce in half a pint of water was prescribed to be taken when the burning pain, arising from the generation of acid in the stomach, was most severe. Two ounces of brandy were also ordered for daily use. Under this plan of treatment there was a very marked change for the better; the pain was relieved, and the vomiting ceased altogether for a week. On the 3rd of December the report was, "it is a week to-day since she vomited, and she has gained strength, and is in every respect better. In the afternoon and evening she has considerable heat and uneasiness at the stomach, which the soda mixture relieves." As the pain was so much relieved, I thought the opium might be omitted, but the day after its omission she vomited again, and the pain returned. The vomited fluid had a little head and odour of yeast, and contained *sarcinæ*, but no *torulæ*. The opium was resumed, and she again improved, and had no return of the vomiting from the 4th to the 10th, when the sulphite of soda was omitted. She vomited the same evening that the sulphite of soda was omitted; it was therefore resumed on the 12th, and she went on very comfortably till the 22nd, though occasionally vomiting fermenting matter. She seemed then very

unwell, and the matter vomited had a very yeasty appearance. The following mixture was ordered: \mathcal{R} Sodæ Sulphitis \mathfrak{v} iiij., Tinct. Lupuli \mathfrak{z} j., Aquæ \mathfrak{z} viiij. \mathfrak{z} j ter in die sumenda.

The addition of the tincture of hop seemed of service, and improved the appetite. On the 3rd of January, the addition of half a grain of the nitrate of silver was made to each of the opium pills, but it did not appear to produce any well-marked beneficial effect at the time it was taken. A trial was also made of charcoal powder, the properties of which have recently been so highly extolled, but it seemed to be perfectly inert.

She finally got tired of remaining in the Infirmary, as so often happens in cases of this description, and on the 29th of January she was discharged.

I have since watched the case, which has greatly improved. The bowels were confined while she was in the Infirmary, and required the frequent use of aperients, but she had afterwards an attack of spontaneous diarrhœa, which seemed to relieve her. On the 18th of April I found her greatly improved in appearance and in health and strength. During three weeks she had vomited only once, and been remarkably free from pain at the stomach. While she was in the Infirmary the diet was carefully regulated, and consisted chiefly of such articles as milk alone, or with arrow-root, beef tea, vermicelli soup, rice pudding, and biscuit.

Remarks. — From the fact of this patient having vomited blood several times before her admission, we have reason to believe that there was ulceration of the stomach; and from the tenderness on pressure and hardness perceived in the situation of the pylorus, we may also conclude that the ulcer existed in that situation. The great fulness and tympanitic sound on percussion, which was perceived when there was food in the

stomach, showed that the organ was greatly enlarged from repeated distension, in consequence of the disease either organically obstructing the passage of the food out of the stomach, or so irritating the muscular fibres of the pylorus as to cause spasmodic stricture. That the ulceration was not of malignant nature, and that the obstruction may have arisen partly from such spasmodic action, appears probable from the length of time the patient had been subject to dyspeptic disorder, as well as from the subsequent marked improvement, which we may, with some reason, attribute to the healing of the ulcer, and the subsidence of the irritation it had caused.

Whilst the diet was carefully regulated, several of the remedies which have been found most useful in stopping this kind of fermentation in the stomach were tried. Tannin was given with the view of checking the abundant secretion of mucus which we regard as the active ferment; but no good appeared to result from it. Mustard appeared to control the fermentive action; but though given in glycerine to shield the stomach as much as possible from its irritating action, it was not pushed as far as would be advisable in other cases where there might be no reason to apprehend the existence of ulceration. The sulphite of soda was less efficacious in stopping the fermentive action in this than in many other cases in which it has been given; and the sesquicarbonate of soda and opium were the remedies which appeared to afford the most decided relief. The addition of nitrate of silver to the opium was made, not with the view of preventing fermentation, but of exciting a healing action in the ulcer; and the experiments I have since made, proving that it is a most active antifermentive agent, show that it is capable of serving a double purpose in such cases; that it is therefore one of the most suitable remedies we can employ in cases

of fermentive disorder where we have reason to apprehend the existence of ulceration, and they afford a reasonable explanation of the value which medical men have attached to it as a remedy in certain forms of dyspepsia.

The next case is one condensed from a clinical lecture* by Dr. Jenner; and it is inserted here, as it was the first case in which the power of the sulphites of potass and soda in checking fermentation with the growth of *sarcinæ* was ascertained. It is also interesting as affording an example of a practical application of chemical knowledge in the treatment of disease.

James Martin, aged 66, formerly a soldier in the Peninsula, suffered for twenty years, dating from an accident in the Thames Tunnel, from very severe dyspeptic symptoms, more especially pain at the stomach, flatulence and vomiting once or twice daily, and on one occasion he had vomited blood. When admitted into University College Hospital, in March 1851, he was reduced to an extreme state of wretchedness and emaciation by the long continuance of his illness, by the severity of the burning pain at the stomach which forced him to sit up in bed, and by the vomiting of enormous quantities of fermenting fluid, amounting sometimes to as much as two quarts at once. The fluid contained *torulæ* as well as *sarcinæ*. Professor Graham, on chemical examination, found much free hydrochloric acid, a little acetic acid, alcohol, and sugar, and he ascertained that the disengaged gas was carbonic acid. The stomach seemed dilated; and about two inches to the right of the median line, midway between the umbilicus and the cartilages of the ribs, an ill-defined tumour could be felt. All the ordinary means, such as hydrocyanic acid, morphia, sulphate of zinc, creosote, and nitrate of silver, having been tried with very little benefit, Dr. Jenner

* Medical Times, August 23. 1851.

resolved to give the neutral sulphites of potass and soda. It had been well known that sulphurous acid was an agent of very considerable power in stopping fermentation and putrefaction, and in destroying low forms of animal and vegetable life, though it has no injurious effect on the stomach itself; and the sulphites being readily decomposed by the acids in the stomach, he conceived that the sulphurous acid set free would stop fermentation, and destroy the *sarcinæ*. The success which attended its administration in this case justified his expectations, and we have thus been furnished with an additional remedy which has proved very useful in the treatment of these cases of fermentive disorder. The sulphite of potass was first tried, and afterwards the sulphite of soda, which is a more stable salt, and can therefore be more depended on. The fermentation was checked, and all the symptoms were remarkably ameliorated in this case; the pain was removed, and the patient gained flesh. The disease was not, however, entirely removed, and the symptoms recurred whenever the remedy was laid aside, so that it was necessary to continue the use of the sulphite.

Dr. Hassall has given an interesting and detailed statement of a case in the person of a medical man who had been troubled for fifteen years with very distressing dyspeptic symptoms. The report from which the following account is extracted is the patient's own statement:—

“W. T——, age 55, habit gouty, temperament nervous, form light and spare, habits unusually temperate; has endured much bodily and mental labour for thirty years; riding on horseback and in a phaeton twenty or thirty miles a day, and sitting up very late at night reading. Became slightly dyspeptic twenty-eight years ago, and felt slight pains in *epigastrio*, with flatulence and anorexia, for about ten years. About eighteen

years ago attacks of pain became more violent, and assumed an intermittent and periodical character. Consulted now, in succession, Dr. Elliotson, Dr. G. Tuthill, and Dr. James Johnson; took charcoal, gunpowder, nitrate of bismuth, prussic acid, creosote, and nitrate of silver, without the least relief. Three years from this period continual vomiting came on, and henceforth the pain in the stomach became greatly relieved. Continued to work in my profession as a surgeon until five years ago, when the vomiting became so distressing and so violent as to compel me to relinquish practice. Now consulted Dr. Prout, who gave no positive opinion on my case, but feared no organic disease. Took, at his advice, the nitrico-hydrochloric acid, without any relief; but after remaining in London a few months the vomitings entirely ceased, and my health became greatly improved. At the end of twelve months went down to N——, having official duty to do at Marlborough. Here I got quite well. From hence I was obliged to consult the health of a delicate daughter by going on to Clifton; and ultimately, in June, 1849, to settle down here in practice. Ever since my residence here, my health has retrograded, and I am now obliged to confine my practice almost entirely to home consultation."

At this time he had frequent severe pains in the situation of the stomach, from acids, and by the distension produced by the wind collected in the stomach and bowels. Vomiting occurred sometimes twice daily, sometimes every day, sometimes every other day, or once in three or four days. He had but little pain when the vomitings were persistent. Intense headache occasionally, and giddiness on rising from his seat, and great susceptibility to cold, muscular twitchings, and painful twitchings in the great toe and thumb. The sight of the left eye was affected, the pulse irregular, and the strength and spirits greatly depressed. The

bowels were invincibly costive, but sometimes loose and yeasty in appearance. The urine generally alkaline, and loaded with phosphates, and the matters ejected from the stomach so intensely acid, that they excoriated the fauces, unless carbonate of potass or soda had been previously taken. Of these he sometimes took to the extent of a pound in the week. "I have tried," he observes, "every species of diet, but do not find the slightest difference; the less, however, I eat, the better I am. I can hardly expect to get entirely relieved after so long suffering; but if you could, after ascertaining the precise character of the vomited fluid, hit upon any drug that would render the presence of the acid less irritating to the stomach, I may, perhaps, have fewer attacks of vomiting, and have a little more comfort."

Dr. Hassall made a very careful examination of the urine, which he found to contain different forms of phosphates; and also a microscopic and chemical examination of the matter ejected from the stomach. The microscope revealed the existence of a great abundance of *sarcinæ*, also the *penicillum glaucum*, and likewise a few sporules of another fungus of a brown colour and circular form, and not previously observed.

The chemical analysis of the contents of the stomach by Dr. Letheby, gave the following result, showing the presence of two free acids, the hydrochloric and butyric:—

Water	-	-	-	-	-	975.82
Free hydrochloric acid	-	-	-	-	-	0.80
Free butyric acid	-	-	-	-	-	1.38
Yellow fatty matter of buttery consistence	-	-	-	-	-	8.00
Extractive matter, soluble in alcohol	-	-	-	-	-	2.42
Extractive matter like gum, soluble in water	-	-	-	-	-	4.00
Albumen	-	-	-	-	-	2.00
Alkaline chlorides, with traces of sulphates	-	-	-	-	-	4.58
Phosphate of lime	-	-	-	-	-	1.00
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"I was, of course, greatly pleased," Dr. Hassall observes, "at the discovery of the sarcinæ, because herein I perceived clearly that I had obtained an important clue by which many of the most urgent and distressing symptoms of the case were to be explained, and by which also the treatment to be adopted with a chance of benefit or success must be regulated. I prescribed bicarbonate of potass and infusion of quassia in mixture, with doses of sulphite of soda to be given repeatedly; I also interdicted fatty and oleaginous articles of diet, and all salt meat. He improved immediately under this treatment, though at first only partially carried out in consequence of the patient being ordered on duty as an army medical man."

After taking the sulphite of soda regularly for five weeks, he gave the following statement of his improved condition:—

"Five weeks to-morrow since I vomited—a longer interval than I have had for the last two years. During the whole period of the enrolment, which terminated five weeks ago, I vomited, on an average, once or twice in two or three days. I attributed this partly to fatigue and mental anxiety, together with irregular living. For the last five weeks I have had nothing to do but to attend an occasional case of illness among the sergeants of the disembodied staff. I have lived very regularly and quietly, taking for the first fortnight, until my stock became exhausted, the sulphite of soda. The result has been, as stated above, that I have not vomited since, or even felt the least nausea. Moreover, I add with great satisfaction that my bowels have become regular, and act without medicine."

The urine had also become natural. He could walk several miles without fatigue, and had invariably sound and refreshing sleep. He adds:—

"Now all the above statements I am sure you will

think most favourable and encouraging ; and I wish that I had no drawback to make from them. I must, however, state my case candidly and truthfully, and therefore add that since I have ceased to vomit, I have had more pain in the stomach, the attacks of which are frequently so severe as to oblige me to take large quantities of soda as heretofore, by which the pains are immediately relieved."

The heart's action was still irregular, the appetite was rather capricious, and there was an imperfection in the vision of the right eye, — symptoms from which he concluded that though there was great improvement in the primary assimilating process, the secondary assimilating process was still considerably deranged. A review of the whole case shows, however, that the patient had derived an immense amount of benefit and relief from the use of the sulphite of soda ; and we must therefore agree with Dr. Hassall that it is both an encouraging and an instructive one. "

Influence of Sarcinæ on Fermentation. — We have already seen that the most able chemists are divided in opinion as to what influence microscopic plants exert on fermentive actions ; and in like manner, whilst some medical men regard the sarcina as an active agent, we find that there are others who assert that its presence in the stomach is an accidental occurrence, which exercises no particular influence on the fermentation there. This assertion is based on the fact that sarcina is occasionally found in the stomach without any sign of fermentation. It was found by Bidder and Schmidt in the case of the Esthonian peasant, Catherine Kütt, who had an opening into the stomach ; and in the stomach of a dog, in which Frericks had made a similar opening artificially. On the other hand, we must not overlook the fact observed in the preceding

cases, that where the conditions of the stomach favourable to the production of fermentation are present, the sarcina is multiplied in great quantity, and appears to produce an influence similar to that of yeast plant. The facts we have also noticed in the previous chapter with reference to the germs of the yeast plant always existing in the atmosphere, ready to germinate in a suitable soil, and the prevention of fermentation by their exclusion, are further opposed to the views of those who would regard the sarcina as an occurrence of little or no pathological importance. The soil, or nidus, in which it grows, seems to be the mucus of the stomach, as it is in the tenacious matter ejected from the stomach that we find it most abundant. Though it has never been found to increase and produce fermentive action out of the stomach, in a few instances sarcina has been found in other situations, but never, so far as I am aware, except in animal fluids. It has been not unfrequently observed in the contents of the intestinal canal, but in such cases was probably generated in the stomach itself. Dr. Virchow on one occasion found sarcinæ in the matter of a pulmonary abscess, and Heller and others have found them in the urine. In one of the cases it was examined for many weeks in succession, and a sediment of an inch in depth sometimes observed, and composed almost entirely of sarcinæ.* Dr. Jenner also found sarcinæ in the fluid of the ventricles of the brain of a highly tubercular child which died at the age of four years. The fluid in this case was alkaline; but it could not be ascertained whether the sarcinæ had formed before or subsequent to its removal from the brain, or whether they had existed during life, or been generated after death. We may also add that the sarcina has been found in the

* British and For. Med. Chirurg. Rev.

stomach of the rabbit and of some of the lower animals.

Relations of Sarcina to morbid Conditions of the Stomach. — The occurrence of sarcina has excited much attention of late years; and I have found recorded in the medical journals and in the works of different authors, above thirty cases in which it was discovered, and these, with the cases I have myself observed, make together thirty-six. In examining them I find that in eighteen, or one half, the death of the patient is recorded; so that it would seem that in a large proportion of the cases, in which this species of fermentive disorder is severe or persistent, it is caused by some organic disease of the stomach or other organs connected with it. In analysing these cases I find that they admit of being arranged together in four series or groups, viz.: 1st. Those cases in which ulcers, or cicatrices arising from them, or some other non-malignant disease of the stomach, obstructed the pyloric orifice. 2nd. Cases of cancerous disease contracting the pylorus. 3rd. Cases in which there was no disease of the stomach itself, but displacement or some other condition obstructing the pylorus. 4th. Cases in which the disorder may have been functional, recovery having taken place more or less perfectly.

First Series, or those cases in which ulcers, or cicatrices arising from them, or some other non-malignant disease of the stomach, obstructed the pyloric orifice, and prevented the exit of the food.

To this series we may refer the first and third of the cases of which I have myself given an account; and also Dr. Jenner's case, in which he discovered the properties of the sulphites. Dr. Todd met with a case of this fermentive disorder in a man 38 years of age, who poisoned

himself with bitter almonds ; and it was found that there was a large ulcer near the pylorus, which had healed, but had caused adhesion to the liver, and dilatation of the stomach. He has also given an account of the case of a gentleman aged 31, who died after suffering for ten years from excessive gastric disturbance, consisting of periodical attacks of vomiting of matter, generally of yeast-like character, and containing sarcinæ. After death, which took place in consequence of rupture of the stomach, this organ was found enormously dilated, and the cause of the dilatation was found to be the cicatrix of an ulcer, which in healing had contracted the pyloric opening. Dr. Ransome has published the case of a man 48 years of age, who had been ill for four years, and vomited large quantities of fermenting matter containing torulæ as well as sarcinæ. He died suddenly, in consequence of perforation of the stomach by a simple ulcer, which had caused contraction of the pylorus to the size of a quill. Contraction of the pylorus from disease external to it, and where the internal part of the stomach itself is sound, may likewise give rise to this disorder ; and Dr. Ransome met with a case where old adhesions from peritoneal inflammation had contracted the pylorus, and caused this disorder during the long period of twenty-three years. Dr. Budd also met with a case in a man 44 years of age, who had been troubled with this disorder for two years in consequence of having met with an injury, which had probably produced similar adhesions near the pylorus. A case occurred to Dr. Todd, of a man 40 years of age, where the pylorus was found to be obstructed by a fungoid ulcer. Mere displacement of the stomach may delay the passage of the food out of the stomach, and cause fermentation, and ultimately dilation of the organ ; and Dr. Miller has related a case of this nature in a lady 48

years of age, who had sarcinæ in consequence of such a condition, without disease of the pylorus.

Second Series.—Cases of cancerous disease contracting the pylorus, and producing fermentation with sarcinæ.

We have had a well-marked example of cancerous disease obstructing the pylorus, and producing this disorder of the stomach, in the second case which I have detailed at page 44. Dr. Todd has given an account of a case in a woman 30 years of age, who had this kind of vomiting; and after death the stomach was found enlarged, and the pylorus contracted by cancerous disease. A case occurred to Dr. Ransome, in which it was found that a small cancerous tumour had acted as a valve in obstructing the pyloric orifice. Dr. Leared has published a case in which he found cancer of the pylorus and dislocation of the stomach from its proper position. A case of a lady, 83 years of age, has been met with where there was vomiting of blood and fermenting matter, and after death two cancerous ulcers were found at the pylorus. The last case of this series to which I have to allude is one observed by Dr. Budd, in a man 40 years of age, who had vomiting of blood and sarcinæ, with all the usual symptoms of cancer of the stomach, but no examination was obtained after death.

Third Series, of cases in which, on examination after death, no disease of the stomach itself was found.

Dr. Barnes has published an account of a lady 60 years of age, long addicted to the use of opium, who died after having had this kind of vomiting of fermenting matter with sarcinæ, and it was found that there was little or no alteration of the stomach; but there was fatty degeneration of the liver, and it is

probable that the enlargement of the organ caused it to press upon the stomach, so as to derange its functions and prevent the free exit of the food. The disease of the liver might also have obstructed the circulation, and caused congestion of the mucous membrane. A case was seen by Mr. Busk, in which there was rupture of the diaphragm from an injury; and the retention of the food in the stomach in consequence of it passing through the rupture was no doubt the cause of fermentation.

The foregoing cases embrace all those I have met with, which can be clearly seen to have arisen from causes of an obstructive nature. In the next case, one observed by Dr. Chambers, in a girl 13 years of age, there was disease of the heart and pain at the stomach, and vomiting, but no sarcinæ were observed during life. After death, however, they were found adherent to the mucus of the stomach, which was free from disease. It is probable, therefore, that congestion of the mucous membrane of the stomach, so frequently caused by disease of the heart, produced increased mucous secretion and the generation of sarcinæ. Dr. Todd has remarked that Dr. Brinton found sarcinæ in the stomach of a patient who died of diabetes, a disease in which this organ is usually of great size, owing to the quantity of food and liquids which diabetic patients are in the habit of taking. Dr. Bence Jones also found sarcinæ in the case of a boy 14 years of age, who died of peritonitis and disease of the kidneys, without any disease of the stomach. Mr. Busk is said to have seen a boy, 15 years of age, who died of hip-joint disease, having had vomiting of sarcinæ, and in this case no disease of the stomach was found.

These cases, in which no disease of the stomach or mucous membrane could be discovered, lead us naturally to the next series.

Fourth Series of cases, those in which the disorder may have been functional, recovery having taken place more or less perfectly.

We have seen that in Catherine Kütt's case there were sarcinæ without fermentation, but the unnatural fistulous opening may have admitted the more ready entrance of the germs of this microscopic plant. Mr. Busk saw a case in a young man, where after a severe injury, causing fracture of the spine, there was vomiting of fermenting matter with sarcinæ once, and only once, the patient having recovered. It is probable that in this case the muscular power of the stomach was temporarily injured, so that the food was not expelled through the pylorus by its contraction, just as we find that injuries of the spine, by paralysing the bladder and preventing expulsion of the urine, produce an alkaline fermentation in this secretion.

Dr. Handfield Jones, in his work, has related a remarkable case of dyspeptic disorder in a gentleman who vomited sarcinæ, but recovered so completely that he was afterwards troubled only with ordinary dyspeptic symptoms when he did not pay proper regard to the state of his digestive organs. Professor Goodsir's case has been already alluded to, in which, from the amount of improvement, we may conclude it possible that the disorder was functional only; but in Dr. Hassall's case it is more probable that there was some organic cause. An interesting case has been published by Dr. Neale, which we shall also place in this series, as there was a great amount of improvement effected by treatment. There was, however, evidence of enlargement of the stomach, and also a saccharine condition of the urine. In this series we may also refer to a case observed by Dr. Bence Jones in a stout man 46 years of age, who had been ill for fifteen years, and was greatly relieved by the sulphite of soda.

We would infer that the disorder may have arisen from functional derangement only, in some of these cases, from the recovery of several of the patients, as well as from the absence of any sign of visible disease of the stomach after death in some of the cases noticed in the preceding series.

I have met with two other cases, which cannot be strictly referred to any of the preceding series. One was a case observed by Dr. Bence Jones, where there was abdominal resistance and large superficial veins. These symptoms and the emaciation of the patient indicated some organic disease, probably a tumour pressing upon the pylorus. The other was a case observed by Dr. Ransome, where there was also a tumour in the situation of the pylorus, with dysenteric symptoms.

From a review of the whole of the cases in each of the preceding series, we would draw the conclusion that this very active species of fermentive disorder, accompanied with the generation of *sarcinae*, is allied in the great majority of cases with some organic alteration, producing obstruction in the pylorus; but it would also appear, from some of the cases in the third and fourth series, that it may likewise arise from causes of a temporary nature, which probably delay the passage of food out of the stomach. As these causes generally produce the less active kinds of fermentive disorder, which we shall have occasion to notice more fully in a subsequent chapter, we shall at present only observe that the causes of this nature which seem most likely to produce fermentive disorder are contraction of the muscular fibres of the pylorus from some irritation of the mucous membrane, and loss of power in the muscular coat of the stomach to propel the food through the pyloric opening, by both of which states the food would be detained an undue length of time in the stomach. It is not improbable, too, that the presence of unnatural mucous secretion, or

of blood, arising from congestion of the stomach, or ulceration, may have an effect in producing fermentive disorder with *sarcinæ*.

Analysis of Symptoms in Fermentive Disorders, with Sarcinæ.—In analysing the thirty-six cases in the preceding series, we find that the disease is more common in men than in women, twenty-four being males, and only ten females, the sex not being mentioned in two of the cases. It would seem that the disease may occur at any period of life, but that it is most common between the ages of 30 and 50.

The disease seems to commence in many cases very gradually, the patient having been often subject to indigestion for many years before the peculiar symptoms of this fermentive disorder have showed themselves. In some cases the patient has been found to have suffered from difficult or painful digestion for as long a period as fifteen or twenty years; and in the case of the woman related at page 45, she had suffered in this way for five years, but had observed the yeasty appearance of the matter vomited only for eight months. In these long-continued cases, even where there is considerable emaciation, we should be rather led to regard the disorder as dependent on simple ulcerative, or other disease of non-malignant nature, than upon cancer, which we know to be a disease which is usually more rapid in its course.

Of all the symptoms, vomiting is the most common. At first it may occur only at intervals of months or weeks, and the patient may then be able to account for its occurrence from the use of some indigestible kind of food. It is most apt to come on after dinner, or in the evening, or during the night, when the quantity brought up is often very great, and contains portions of the previous meals half digested. The matter vomited is ex-

tremely acid, this having been an invariable characteristic whenever the sarcina has been found. The colour of the matter vomited varies, and appears to be a good deal dependent on the kind of food which has been taken. I have seen it of a white colour when milk diet had been used, or of a dirty grey colour like yeast, or of a greenish hue. The chocolate-brown colour seems, however, to be the most characteristic, and the sarcina itself has a brownish-yellow colour. The yeast-like frothy appearance, and the smell, have been already sufficiently noticed. The presence of the yeast plant, in addition to the sarcina, was noticed in thirteen of the cases, and the penicillum glaucum in two; but it is not improbable that the presence of these plants may have been overlooked in some of the other cases. The occasional occurrence of blood in the matter thrown up is another important symptom which we find noticed in five of these cases, and in one there was matter like coffee-grounds brought up. In two there was also blood in the motions. Pain is the symptom which stands next in importance to vomiting, and it seems to be absent in scarcely any. Its extreme severity or intense burning character is noticed in fourteen of the cases; and in the case where there was fatty degeneration of the liver it was intense and spasmodic. It is especially felt after taking food, and in one case it was aggravated more particularly by solid food. The number of causes from which the pain may arise sufficiently accounts for its being so constant a symptom. In those cases where we have reason to believe that the fermentation arises from mere disorder of function, the irritation produced by the presence of the acids—the acetic, lactic, hydrochloric, and especially the butyric, all of which have been found in the matters ejected from the stomach—is sufficient to cause pain. The flatulent distension produced by the gases generated during fermentation must also induce

it, and spasmodic contraction of the pylorus may be an additional cause. In the organic diseases of the stomach we have other causes of pain added to these, more especially in cancer of the pylorus, which is itself a cause of severe pain. When we consider the irritating properties of the acids formed, we need not be surprised at the burning, agonising nature of the pain in some cases of this disease where there is ulceration of the stomach, or that the wish should sometimes be expressed by the patient that it were possible to live without food. Flatulent distension is another prominent symptom which arises from the gases generated during the fermentation, more particularly the carbonic acid, and hydrogen gases; and the distension of the stomach produced by them and by the copious secretion of gastric fluid, which is prevented from passing through the pylorus, occasions the increase in the size of the stomach so often noticed in this disease, and which is often palpable on examination of the epigastrium. Another symptom not unfrequently complained of is a feeling caused by the fermenting movement, as if there were something alive in the stomach.

The tongue does not present any characteristic appearance indicative of this disease. The bowels are usually costive, and the motions have been observed to be perfectly black in several cases. The disease is a chronic one, in which we have no characteristic alteration of the pulse, or any febrile disturbance. Nutrition is, however, seriously interfered with, and when the disease has lasted long there is almost always emaciation, weakness, and pallor; but in a few instances there has been freshness of colour, and even some degree of stoutness. Want of sleep has been complained of by many. The urine has been found alkaline by Dr. Bence Jones, when much acid has been vomited; sugar has been

discovered in it; and oxalate of lime crystals in several instances.

There are certain symptoms, the presence of which should lead us to infer the existence of organic alteration; for example, the existence of any enlargement or hardness in the situation of the pylorus, or any unnatural dulness on percussion there. When the patient is beyond the age of 40, and the disease has been present only for a few months, or not more than one or two years, but has yet produced great weakness and emaciation, we may suspect the existence of cancer, and especially if there be the peculiar cachectic complexion, lancinating pain, or vomiting of blood or coffee-coloured fluid. If, on the other hand, the disease has existed for a series of years without producing such marked emaciation, and if there have been intervals of comparative freedom from the vomiting and severe dyspeptic symptoms, we should have ground for thinking that the stricture might be of simple or non-malignant nature, and if the patient had been intemperate we should have a reason for considering that it might be the result of a species of hypertrophy of the pylorus which is sometimes produced by drinking to excess. The existence of pain in a particular spot, and immediately aggravated by taking food, would constitute a reason for thinking that there might be an ulcer; and if at intervals of months, or even of years, there had been attacks of vomiting of blood, we might conclude with a great degree of certainty that there was ulceration near the pylorus, or a contraction resulting from the healing of an ulcer. On the other hand, the absence of any tumour and of acute circumscribed pain, and of any attack of vomiting of blood, would, especially if recovery were to take place more or less perfectly, constitute the best grounds for believing that the disorder might be of merely functional nature.

We shall examine the nature of the fermentive actions which occur in the stomach in a succeeding part of the work, and I shall only now remark, that we have evidence of the occurrence of several kinds. The vinous undoubtedly occurs in all those cases in which the torula is found, and in more than one instance alcohol has been obtained by distillation from the fluids ejected from the stomach. In the presence of lactic, acetic, and butyric acids, we have also evidence that these kinds of fermentation likewise take place in the stomach.

Treatment of Fermentive Disorder with Sarcina. —

The treatment embraces three principal points for consideration, viz., the dietetic management, the use of antifermentive remedies, and the use of those necessary for the relief of structural lesions.

The selection of proper articles of diet is a matter of very great importance; and we should endeavour, on the one hand, to choose such as admit of being easily digested, and so entirely dissolved in the stomach, as to leave little or no residue to pass through the pylorus; and, on the other hand, we should studiously avoid the use of such as are prone to pass into fermentation, more especially fermented liquors, and bread which has been made by fermentation. Unfermented biscuit is, therefore, to be given instead of bread. We know that the stomach has the power of entirely dissolving albuminous and gelatinous kinds of aliment; that the digestion of amylaceous substances goes on in the stomach, and that saccharine matters are absorbed by the vessels of the stomach. We should, therefore, select as diet such articles of food as contain these aliments in the most easily digested forms. Milk is at once a nutritious aliment, and one which undergoes complete digestion in the stomach. It may be given alone, in small quanti-

ties at a time, or still better, when thickened with arrowroot or other farinaceous substances, which prevent its coagulation in the stomach into a solid mass, which resists the solvent action of the gastric juice. Boiled milk, mixed with one third or one half of lime water, has an astringent action on the mucous surface, and it checks vomiting in many cases of dyspepsia. Like the alkalies, it has also antifermentive as well as antacid properties. Beef tea or mutton broth made with vermicelli, or rice, and freed from fat, are also suitable articles, and likewise calf's foot jelly. In those cases where we have reason to suspect ulceration, a similar dietetic system should be adopted; and Dr. Budd makes the following judicious remarks on the most appropriate kinds of food in this condition:—
“Milk, and compounds of milk, with farinaceous substances, which would make a soothing poultice for an ulcer of the skin, are the articles of food which are the most soothing, or rather which cause the least pain, in ulcer of the stomach, and are therefore those on which the patient should mainly subsist. As a diet of this simple kind requires to be persevered in for a considerable time, especially when the ulcer is large or of long standing, care should be taken that the milk is of good quality, and the farinaceous substances given with it should be of the most nutritious kind.” He also recommends maccaroni, semolina, biscuit powders, and other substances made from flour, and Indian meal where there is no repugnance to it. The yolk of eggs, beat up with brandy, may be given; and in all cases where a stimulant is necessary, it is better to select a spirit such as brandy, on account of its antifermentive properties, in preference to wine or any fermented liquor. When, however, there is cause to suspect the presence of an ulcer in the stomach, the use of stimulants should, as a general rule, be avoided as much as possible. Where

the disease arises from cancerous contraction of the pylorus, the same dietetic rules are applicable.

Since the nature of this fermentive disorder has become better known, the attention of medical men has been more directed to the use of antifermentive remedies in the treatment of it. But our investigation into the causes of the disorder, which has shown that they are most frequently of organic nature, explains to us how it is that the sulphite of soda and other remedies of this class act more frequently as palliative than as curative remedies. It appears to have a more decided power in arresting this kind of fermentive action, and in destroying the sarcina, than any of the remedies yet tried for this purpose; and in some instances the relief experienced by the patient has been most gratifying, after various other means had failed. In some cases, however, though the fermentive action and the vomiting have been stopped by it, there has been no relief from the pain, but, on the contrary, it has been aggravated, apparently from some of the half-digested food, which would have been ejected had the fermentation and vomiting continued, having lodged about the pylorus. Creosote is another antifermentive remedy which has been much used; and it appears to act not merely by checking fermentation, but also as a sedative in relieving pain. Wood spirit, it is well known, is as efficacious a remedy as creosote in stopping vomiting; and, from the energetic power which I have found it exerts in arresting fermentive action, it would seem to be a remedy worthy of trial in this disorder. Common salt was found very efficacious in one instance observed by Dr. Budd; and there are no remedies which have been more resorted to by the patients themselves than the alkalies, which have been often taken in enormous quantities. From my experiments, it would seem that they do not act merely by neutralising the acids in the stomach, but

also as energetic antifermentive remedies. Allusion has already been made to the antifermentive properties of mustard, which should cause it to be more freely used in such cases, especially as a condiment.

We shall not here enter into any extended examination of the treatment that may be necessary for the relief of the various organic affections, which we have found, may accompany this fermentive disorder; but we would observe that where there is ulceration of the stomach, whether of simple or cancerous nature, the pain and irritation will be relieved by the use of alkaline remedies, or by magnesia, which is one of the best antacid remedies in such cases, and they may be combined with a sedative such as hydrocyanic acid. The metallic astringents are useful in simple ulcer, especially the milder preparations of iron and the nitrate of silver, and opium is the best sedative for the relief of pain. Opium and morphia are also the sedative remedies on which we may place the most reliance for the relief of pain in every stage of cancerous disease. I may here observe that in the case of a lady who had cancer of the stomach and liver, and vomiting, which none of the ordinary remedies could control, it was relieved by small doses of strychnine, and after having been supported for a time with nutritive injections, she was enabled to retain food in the stomach, and life was thus prolonged for two months. In cases of vomiting of sarcina with great pain and irritability of the stomach, the strength of the patient might be temporarily sustained, while the stomach might have a respite from its painful work by using nutritive injections made with beef tea, starch, &c.

CHAP. IV.

DYSPEPTIC DISORDER WITH FERMENTATION.

CONDITIONS OF MUCOUS MEMBRANE OF STOMACH IN DYSPEPSIA. —
 INFLAMMATION.—ACUTE.—CHRONIC. — TREATMENT. — CONGESTION.
 — ITS CAUSES. — INDIRECT EFFECT OF MERCURIAL PURGATIVES IN
 REMOVING IT.—HOW CONGESTION CAUSES FERMENTIVE DISORDERS.
 — CATARRH OF THE MUCOUS MEMBRANE. — EFFECT OF CATARRHAL
 MUCOUS SECRETION IN CAUSING FERMENTIVE ACTIONS. — ANÆMIC
 CONDITION. — SYMPTOMS OF ANÆMIC DYSPEPSIA. — CONNECTION
 BETWEEN ANÆMIA AND ULCER OF THE STOMACH. — ILLUSTRATIVE
 CASE.—TREATMENT OF DYSPEPSIA FROM ANÆMIA AND CHLOROSIS. —
 EFFECT OF MORBID CONDITIONS OF STOMACH IN CAUSING FER-
 MENTIVE ACTIONS. — VARIETIES WHICH OCCUR IN THE STOMACH.
 — ALCOHOLIC, LACTIC, AND BUTYRIC ACID. — ACETOUS. — SACCHA-
 RINE. — FERMENTIVE ACTIONS IN THE BOWELS. — THEIR EFFECT
 IN CAUSING DIARRHŒA, COLIC, ETC. — CASE WITH INTESTINAL
 OBSTRUCTION.—FERMENTIVE ACTIONS IN OTHER ORGANS. — IN THE
 BLADDER. — IN THE BLOOD.

IN our inquiries into the morbid conditions of the stomach, which produce the sarcinic form of fermentation, we have had occasion to draw attention to the influences which are most powerful in causing this very active species of fermentive action. In examining, also, in a previous part of the work, the kinds of fermentation best known to the chemist, we have seen that they are very numerous, and we shall now proceed to show that other kinds of fermentive action produce many of the ordinary forms of indigestion, that in fact abnormal fermentive actions are the great cause of derangements in what is called primary assimilation.

It is not my intention to enter into any examination

of the different varieties of dyspepsia, which have been described by systematic writers under such names as the atonic, the irritable, or the follicular. From the description of such unmixed forms which can hardly be said to have any real existence in nature, the disorders of the stomach being always more or less intimately connected with derangements of associated organs, such as the liver, or with disordered states of the general health, we derive only very vague and unsatisfactory ideas; and the practical physician is obliged to consider, not which of these forms of the disease he may have to treat, but, after examining the causes, the symptoms, and the state of the general health, to lay down such rules as experience has taught him to be requisite, and to use such remedies as he has found applicable to the particular symptoms of the case, such as heartburn, acidity, flatulence, or pain at the stomach.

We shall therefore rather proceed at once to consider the effects which certain morbid states of the mucous membrane of the stomach, which are known to occur, and to affect its secretions, must have in producing some of the functional disorders which we call dyspeptic. These states are, the inflamed, the congested, the catarrhal, and the anæmic.

1. *Inflammation* may occur in the mucous membrane of the stomach in various degrees of acuteness and severity, just as it may take place in the mucous membrane of the lungs, or of any other organ. Inflammation of the mucous membrane of the stomach is most frequently caused by irritating substances applied to it. The use of indigestible or irritating kinds of food produce it, and excesses in eating and drinking, and especially the use of ardent spirits. It occurs in the course of some fevers, and it is caused by poisons, some of

which, like arsenic, affect it not only when taken into the stomach, but will also cause intense inflammation when merely applied to a wound externally. This shows us that the presence of a poisonous or morbid matter in the blood may suffice to produce gastric inflammation, and explains how inflammation of the stomach should sometimes occur suddenly, and in a very violent form, in gouty persons in whom there is a morbid matter poisoning the blood.

In the less violent forms of the disease there is pain on pressure at the pit of the stomach, or a sense of weight and uneasiness. There is thirst and loss of appetite, with a desire for cold drinks. There is also nausea, and if the patient vomits, the matter brought up is colourless, and contains ropy mucus. The tongue is furred, and generally red at the edges. There is loss of appetite, and dislike to animal food. The patient feels chilly, and has often dryness and heat of skin. In the most acute form of the disease, caused by poisonous irritants, the burning pain at the stomach, the thirst, and prostration of strength are very great. In the case of a lady who unfortunately took by accident a wineglassful of the strong solution of chloride of zinc in hydrochloric acid, a fluid commonly used for disinfecting purposes, the symptoms were of a severe description, though milk, soda, lime water, and albumen were speedily given as antidotes. The first symptoms were, burning pain and vomiting, coldness of the extremities, and tendency to sink. There was also some diarrhoea, and after this she rallied, but the tendency to sink frequently recurred, though the pain and vomiting abated under the employment of opiate enemata. Injections of beef tea and brandy, which had repeatedly roused the sinking pulse and powers of life, ceased to produce this effect; and though she had become able to swallow fluids and to take a little wine whey, she

sank about sixty hours after taking the irritant fluid, which had caused intense gastric inflammation.

The effect of indigestible and irritating food in causing inflammation of the mucous membrane was well observed in the case of Alexis St. Martin, the Canadian, by Dr. Beaumont, who had the rare opportunity of actually seeing it through an opening in the side. He observed that, after he had used such kinds of indigestible food as fried sausages and roasted oysters for some days in succession, or had taken ardent spirits freely for some days, the mucous membrane became red and irritable, and that aphthous patches and red spots were visible. At the same time very little gastric juice was secreted, but instead of it the stomach poured out a quantity of ropy mucus, and the food consequently remained long undigested, and by its presence seemed to add to the irritation. On the other hand, the inflammation subsided speedily under the influence of low diet and cooling drinks.

When the dyspepsia arising from this condition is neglected, and the individual continues to take or returns to the use of solid food in too great quantity, and takes fermented liquors before the inflammation has subsided entirely, it becomes chronic, and fermentive disorders arising from the morbid mucous secretion, and the slow digestion of the food in the stomach, are set up. "The chronic inflammation so excited," observes Dr. Budd, "is attended with an increased secretion of mucus, and causes a thickening, and the so-called mammillated appearance, and occasionally, I believe, minute superficial ulcers of the mucous membrane. Its most constant symptoms are, slight tenderness at the epigastrium, slowness of digestion, pain or tenderness in the stomach, and occasional vomiting after meals, especially after meals of solid food, and a white and furred tongue. The matter vomited contains

viscid mucus, which now and then presents a few streaks of blood more or less altered. The disorder, even after it has lasted a considerable time, disappears readily if the stomach be allowed sufficient intervals of rest, or the patient be restricted to cooling drinks, and a diet consisting entirely of farinaceous substances, and milk."

In drunkards this chronic inflammation sometimes causes a deposit of lymph beneath the cellular tissue at the pylorus, producing an indurated constriction, which we have noticed as being one of the organic causes of the sarcinic fermentation.

This form of dyspepsia, arising from inflammation, would be very easily treated, provided we could always induce the patient, before the disease has become chronic, to confine himself to a mild restricted diet, consisting of farinaceous food, milk, and broth, and the use of cooling acid drinks. Some medicinal treatment will also, in many cases, be of service, such as saline effervescing medicines, with hydrocyanic acid, and mild mercurial aperients, to promote the action of the liver.

2. *Congestion* of the mucous membrane of the stomach is an obstructed state of the circulation, which renders it more liable both to inflammation and the catarrhal condition presently to be noticed. It is produced by obstruction of the venous circulation, and arises sometimes from the return of the blood being retarded by disease of the heart or lungs, but more frequently from disease of the liver, through the portal system of which organ all the blood returned from the stomach must pass before it can reach the heart. When there is much congestion of the stomach, the mucous surface readily admits the exudation of blood from its very vascular surface, and hence we often find patients who have disease of the liver, obstructing the circulation, attacked with vomiting of blood; and sometimes, also,

those in whom there is disease of the heart or lungs, which produces a similar state of the stomach. A slighter degree of congestion of the mucous membrane of the stomach, producing loss of appetite and deranged digestion, is very commonly caused by a suspended or disordered state of the secreting function of the liver; and when there is such a torpid state of the liver, patients very frequently recognise it themselves, and tell us that they feel bilious.

Congestion of the mucous membrane of the stomach must have a powerful influence in causing fermentive disorders, as it arrests the secretion of the healthy gastric juice capable of dissolving the food, while at the same time it causes the presence in the stomach of not only unnatural mucus, just as congestion of the lungs causes an unnatural mucous secretion from the bronchial mucous membrane, but also of blood, which is an albuminous fluid, capable of acting as a peculiar ferment; and it would seem, from recorded cases of fermentation with *sarcina*, that this microscopic plant is not unfrequently generated in the blood exuded into the stomach.

In those cases where congestion comes on very gradually from chronic disease of the liver, the lungs, or the heart, the vessels of the stomach have, to some extent, the power of resisting the obstructing influence, or so accommodating themselves to it that no blood is effused. In pulmonary consumption the congestion comes on in this very gradual way, and is known to us more by some of the less violent symptoms; the congestion induced in the stomach by the gradual obstruction of the pulmonary circulation being one of the causes of the dyspeptic symptoms, and vomiting, from which so many consumptive patients suffer, more especially in the advanced stages.

Obstruction of the circulation, and secretions of some

other organs, also tend to cause congestion of the stomach, and thus we find a stoppage of the monthly courses in females is often the cause of sickness and gastric disorder, and in some instances it even produces such an amount of congestion that vomiting of blood occurs. The exudation takes place, no doubt, in some of these cases from an ulcer in the stomach; but in many others, where it recurs at monthly periods, it arises simply from the congestion and exudation of blood from the whole mucous surface.

The beneficial effects of mercurial aperients in removing congestion of the stomach, produced by a torpid state of the liver with deficient secretion of bile, must be attributed not simply to the removal of biliary accumulations, but to the greater freedom thus given to the circulation through the liver, and to the return of the venous blood from the stomach.

The state of congestion of the stomach arising from these obstructive causes has a very marked influence on the gastric secretions. The gastric juice is diminished in quantity, whilst an unnatural secretion of thick ropy mucus takes place. Dr. Budd observes that when the stomach and intestines are long kept in a state of congestion from a bar to the passage of the blood through the liver or the lungs, the nutrition of the mucous membrane is less active than in health; its peculiar and solvent juice is more sparingly secreted, and in consequence digestion is slower and more feeble.

We have already shown, in reference to inflammation of the mucous membrane, that these conditions delay the passage of the food out of the stomach by preventing its solution, and producing an unnatural ferment, and they act therefore powerfully in inducing fermentive disorders.

3. The *catarrhal* state of the mucous membrane of

the stomach is a condition similar to that which the lining membrane of the lungs assumes when affected by cold. It is a species of chronic inflammatory irritation which is apt to succeed to congestion or inflammation. It causes a secretion of watery mucus, which often produces sickness or vomiting, and this constitutes the dyspeptic disorder commonly called pyrosis, or waterbrash. Dr. Handfield Jones, who has particularly described the state of the stomach in this affection, observes that it is exceedingly common, and occurs under the same influences as catarrh of the air passages. The secretion in pyrosis may be alkaline, but it more frequently becomes acid in consequence of the mucus causing fermentation in the food contained in the stomach. He states that the middle and pyloric regions of the stomach are the parts principally affected in catarrh, whilst the splenic region is the part affected in gastritis. There is a great secretion of mucus in this disease, and he remarks, that when a layer of tenacious alkaline mucus is spread over at least half the surface of the stomach, it may be well conceived what an impediment it must be, by its mere presence, to the digestion of the food. Even if the subjacent membrane be capable in any degree of pouring out healthy secretion, this viscous covering must prevent it coming in contact with the ingesta. He considers it the most common of the unnatural conditions of the mucous membrane. It is produced not only by atmospheric states, but also by indigestible substances; and as it causes not merely a diminution of the healthy gastric secretion, but also a secretion of a greater or less quantity of unhealthy mucus, which has the power of acting as a ferment, there can be no doubt that this catarrhal condition acts in a similar way to the two previous states of the stomach we have described, and that it is a common and powerful cause of fermentive disorders.

4. The *anæmic* condition of the mucous membrane is a very common cause of slow and painful digestion. It is observed in its simplest form in persons who have lost large quantities of blood from any cause, and in whom the digestive powers have in consequence become so impaired, that they are able to digest only the lightest kinds of food, and are subject, if they partake of the less digestible kinds, to suffer from pain at the stomach, eructation, and even sickness and vomiting. This condition occurs also in chlorosis and other forms of anæmia where a defective or morbid condition of the blood has developed itself from other causes.

In 1846 I published in the "Lancet" a series of lectures on anæmia, and on the functional disorders which arise from this condition of the blood in which the red globules are deficient, and I then directed attention to this form of indigestion, more especially as it occurs in the kind of anæmia in females to which the name of chlorosis is commonly given.

I showed that disorders arising from anæmia affect in some cases the functions of the brain and nervous system, in others the heart or the lungs; and that in many the stomach is the organ most prominently affected. I also pointed out the importance of referring the symptomatic disorders of these various organs to their true cause, viz., the deficient or altered state of the blood. A table was given of 164 well marked cases of anæmia, in all of which there was a distinct venous murmur in the neck, indicating deficiency of the red globules. In eighteen of these cases dyspeptic disorder was the most prominent symptom. I condense the following account of the symptoms from these lectures:—

"The power of the digestive organs is weakened by anæmia, in whatever way induced. Andral observes that 'for the natural performance of the process of

digestion it is necessary that the stomach should become the seat of a certain degree of sanguineous congestion, which in anæmic individuals cannot take place.' The first and most simple effect of anæmia upon the stomach is a diminution of its ordinary power, so that digestion becomes laborious, and is performed slowly; and thus the individual becomes sensible, often painfully so, that the process is going forward. It must be evident that derangement will not rest here; that if the process be slow, it will be imperfect also. The most common symptom is a feeling of weight and uneasiness after a meal, with flatulent distension, and this continues until the process of digestion is finished, when there is for a time relief from the uneasy feeling. Where the sensibility of the nerves of the stomach is much increased, there is eructation of the food from half an hour to an hour or more after a meal, and it is brought up into the mouth, in a half-digested state, by the contraction of the muscular fibres of the stomach. This kind of ruminating process we find very common in chlorosis, and we not unfrequently find patients say that they cannot keep the food upon the stomach, even though they have usually no sickness. In fact, the uneasiness which they suffer causes them to seek relief by endeavouring to bring the food off the stomach by an effort which is partially voluntary. In some cases, too, the pain experienced during digestion is so severe that the patient would almost rather be without food, and in chlorotic females we find an especial dislike to animal food, which seems to cause the pain more than any other sort. Digestion is not only slow and painful, but it is also imperfectly performed; and there is acidity or heartburn, and increased secretion from the relaxed and weakened mucous membrane, causing pyrosis or water-brash. The functions of other organs concerned in the process of

digestion are deranged, not only directly from the state of the blood, but also secondarily from the disorder of the stomach, and the liver is frequently torpid. In an early stage the bowels are usually constipated; but in very advanced cases there may be diarrhœa, anæmia producing general relaxation of the mucous surfaces, and hence the frequent occurrence of leucorrhœa, as well as of catarrhal states of the bronchial mucous membrane."

This description of the symptoms of anæmic dyspepsia, which I drew up several years ago after careful observation of it, corresponds very closely with that given of the early dyspeptic symptoms experienced by many of those in whom the disorder ultimately lapsed into the sarcinic form of fermentation and vomiting. I also at that time put forward the opinion that the perforating ulcer of the stomach was often the effect of the anæmic cachexia, and in illustration I published a case of severe anæmic dyspepsia, where I believed that ulceration had resulted from chlorotic disease. The case was given as follows: * "Mary D——, aged 20, was admitted into the Liverpool Northern Hospital on the 15th of July, 1845, on account of severe pain at the stomach of long standing. About four months before she had been under treatment for this complaint, which had been at that time accompanied with vomiting of blood. She got much better, though not perfectly well; the pain had returned with its former severity about a month before her admission. She was of light complexion, and had a pale chlorotic appearance. The tongue was clean, not very pale, but looked as if it had been soaked in water, and there were many transverse and longitudinal lines upon it. The papillæ, towards the point, were unusually developed, but unaltered in colour. There was no thirst; the pain at

* Lancet, March 21. 1846, p. 317.

the stomach was very severe, and increased by taking food, but it was somewhat relieved by warm drinks. It came on most severely from half an hour to an hour after dinner, and was often attended by sickness and vomiting. There was pain over the cardiac extremity of the stomach on pressure; the bowels were regular, and the motions natural; the catamenia were formerly present every fortnight, and profuse; of late they had been every three weeks, and were scanty; at these times the pain at the stomach was increased. There were noises in the ears, much giddiness, and pain in the temples and forehead. There was shortness of breath; palpitation on exertion, but no murmur at the heart; pulse 70, weak. There was loud and perfectly continuous venous murmur in the right internal jugular vein, accompanied by a slight thrilling sensation, felt when the finger was applied in the same situation. An aperient powder was prescribed with rhubarb, magnesia, and mercury with chalk. Five grains of citrate of iron, in an ounce of infusion of calumba, with a drachm of compound tincture of cardamoms, were prescribed to be taken three times a day; bread and milk for breakfast, and bread and meat for dinner, were ordered as her diet. 22nd. The appetite had improved, and the pain at the stomach had diminished, though it had been better and worse from day to day. 30th. She was improving, though slowly; she had still the venous murmur, and lightness, but no pain in the head. The pain of the stomach was still occasionally present, and on the preceding evening it had been very severe, and accompanied with sickness and vomiting. The catamenia were present. A grain of the iodide of iron, in an ounce of infusion of quassia, was prescribed instead of the citrate. Her health steadily improved under the use of this, and the dose was gradually increased. August 25th. She was taking, three times a day, a

brachm of syrup of the iodide of iron ; she was then almost well, except that she had a pain below the left shoulder, extending forward towards the lower ribs, for which a belladonna plaster was applied. 29th. She felt quite well ; she had more colour ; her tongue had become redder, and almost quite natural ; she had no giddiness, and no pain at the stomach. The venous murmur was almost inaudible, except during inspiration. She was then dismissed, cured."

I am now enabled to give the subsequent history of this case, which confirms the opinion I had formed as to the existence of an ulcer in the stomach at the time the patient had been under treatment, and likewise as to the close connexion between the perforating ulcer of the stomach and the anæmic cachexia, and this view is, I believe, now very generally entertained by the profession.

She was again admitted into the hospital on the 6th of December, 1848, with symptoms of subacute peritoneal inflammation. A fortnight before, she had been suddenly seized with intense pain at the stomach, and other symptoms of perforation, which had subsided, but she had gradually got weaker. She died fifteen days after admission, and on examination it was found that there had been acute peritoneal inflammation, which had produced adhesion of the intestines, and a partially circumscribed collection of matter in the pelvis. The condition of the stomach was the most interesting feature in the case. There was a contraction of the centre of the stomach arising from a cicatrix on the lesser curvature, and on each side of it there was an ulcer, one of which had caused perforation of the stomach and the peritoneal inflammation, of which the patient died, after surviving much longer than is usual in such circumstances. The cicatrised ulcer, which had produced the contracted appearance at the centre

of the stomach, had no doubt healed while she was the first time under treatment in the hospital; but more than three years after two fresh ulcers had formed, one of which had completely perforated the stomach, allowing the food to pass through, and causing the inflammation and suppuration of which she died, after surviving an unusual length of time, viz., thirty-one days.

The anæmic form of indigestion is one in which spasmodic pains are often experienced at the stomach, which may arise from undigested pieces of food being arrested at the pylorus by the contraction of the muscular fibres, the nervous system being often very excitable in chlorotic females, who are so subject to this disorder. We find, too, that in cases of hysterical sickness and vomiting there is often some irregularity in the uterine functions, and that the peculiar irritability of the stomach is in great measure due to an anæmic state. This I remarked in the case of a young lady who had sickness and vomiting almost every morning after breakfast, with occasional aggravated paroxysms, and attacks of fainting coming on at monthly periods.

The anæmic state of the stomach, by enfeebling the natural function of the organ which is more particularly the secretion of healthy gastric juice, must render the digestion of the food slow and difficult; and, as we know that when the food remains long in the stomach it acts as an irritant, causing unnatural mucous secretion, we can easily see how this condition must, like those we have previously described, tend to produce fermentation; and it is evident that the heartburn, acid eructations, sickness, and gastrodynia, so common in chlorotic females, are caused by fermentive actions.

There are other conditions of the body and mind which produce an effect similar to that of the anæmic state in diminishing the proper gastric secretion. Thus, excessive study, or great mental excitement, by divert-

ing the blood to the brain, may have such an effect, and excessive fatigue, anxiety of mind, and the depressing passions not only depress the nervous system, but also enfeeble the circulation of blood in the mucous membrane of the stomach, and render the digestion of the food slow and difficult, by diminishing the natural secretion of gastric juice.

As respects the treatment of the anæmic form of dyspepsia, I shall not here enter into it further than to observe that the leading point to be kept in view is the improvement of the general health and strength by such tonic means as have the effect of increasing the red globules of the blood, and thus restoring its natural condition. For this purpose we rely chiefly on the employment of the milder, and afterwards of the stronger preparations of iron, and on light nutritious diet, till the stomach becomes able to bear the stronger kinds of animal food. The preparations of iron are the only remedies which can directly increase the red particles, and its introduction into the system is often most effectually accomplished by the use of chalybeate waters. At Harrowgate, in this country, at Spa, in Belgium, or at Schwalbach, Brocklet, or Brucknou, in Germany, the introduction of the mineral is often more effectually accomplished by the use of the waters of these places, the treatment being assisted by the pure, bracing atmosphere, the exercise which is taken in a pleasant country, the freedom from anxiety, and the cheerful society which is met with in watering places.

DYSPEPSIA WITH FERMENTIVE ACTIONS.

The conditions of the mucous membrane of the stomach, which have been noticed, are the most important of those which can be clearly shown to have the effect of producing fermentive actions in the stomach, but we

also know that the inflamed, congested, catarrhal, and anæmic states do not always exist singly, but are often variously combined. There seems to be one effect common to all these states, viz., a diminution of the natural secretion of gastric juice, and they appear also to have the effect of causing increased secretion of mucus, both directly and also indirectly, through the irritation induced by the slow digestion and prolonged detention of the food in the stomach. In the sarcinic form of fermentation these states of the mucous membrane also exist, and are superadded to the organic causes, which we have seen to be so often present in this most active kind of gastric fermentation, where the organic stricture seems to have merely the effect of giving greater force and development to chemical actions which occur in persons of weak digestive powers, in whom we have the following chain of disordered action: — slow digestion, prolonging the stay of the food in the stomach; irritation consequent on this, and causing unnatural secretion of mucus; contraction of the pylorus, sometimes of spasmodic nature, and producing pain and sinking sensation, and this acting for a time as an organic stricture in opposing the exit of the half-digested food. Here, then, we have the same conditions which produce sarcinic fermentation, with this difference, that the fermentation from organic stricture of the pylorus arises from a permanent condition, whilst the fermentive actions which arise simply from the functional disorders we have noticed may be completely and permanently removed by proper treatment and attention on the part of the patient to diet and regimen.

We have seen that healthy gastric juice is a fluid which has an energetic action in stopping fermentation and even putrefaction, and thus it can correct the fetor of tainted meat. "Pure gastric juice," Lehmann ob-

serves, "antagonises the ordinary processes of fermentation, and hence lactic, acetic, and alcoholic fermentation are excluded from the sphere of gastric digestion, so long as this process is a normal or physiological one."

On the other hand, we have seen that mucus has the power of acting as a ferment, and we have noticed the statement made by Gmelin, that the mucous membrane of the stomach, and even that of the bladder, have the power of causing different fermentive actions, according to the state of decomposition into which they have been brought, and that thus a solution of sugar may be made to undergo the lactic, mucous, or alcoholic fermentation.

From the foregoing facts it must be evident that the stomach presents, in the disordered states we have noticed, all the conditions necessary for the development of many varieties of fermentation. There is first of all a deficiency of the antifermentive agent which dissolves the food, and there are those conditions as respects temperature, moisture, access of atmospheric air, and the presence of a ferment, which are known to favour these actions, whilst there is also in the food the saccharine and amylaceous substances capable of undergoing fermentation.

Lehmann observes, that "in the normal condition the stomach, when it is empty, is invested with a layer of mucus which exhibits no reaction with vegetable colours. In gastric catarrh this mucus accumulates in larger quantities, and on chemical examination is found to present little difference from the secretions of other mucous membranes; and like them, it only in a slight degree possesses digestive powers on the addition of a free acid; even while in the stomach it appears to undergo decomposition, and subsequently, on being mixed with amylaceous or saccharine food, to enter into

abnormal processes of fermentation, as, for instance, acetic, butyric, and lactic fermentation. The contents of the stomach, then, contain far more free acid than occurs in them in normal digestion. The two last-named processes of fermentation are especially promoted by the presence of fat, which gives rise to heart-burn, a sensation of constriction in the throat, and vomiting, and at the same time there is often a revulsory (antiperistaltic) motion of the intestinal tube, which causes a regurgitation of bile into the stomach, and this is an additional impediment to digestion."

We have in the second chapter examined the kinds of fermentation best known to chemists, and in this we have endeavoured to show what are the conditions of the stomach which favour the occurrence of such actions there. We proceed now to inquire which are the fermentive actions which are actually known to take place in this organ.

There can be no doubt whatever that the *vinous* fermentation occurs in the stomach, this being clearly proved by the fact that alcohol has been distilled from the matter rejected from the stomach in three cases of vomiting of *sarcinæ*; and as we have seen that the yeast plant has been found in fully one-third of these cases, it is probable that the vinous precedes or accompanies the acid fermentation with *sarcinæ* in a large number of such cases. . We know, too, that new or imperfectly fermented liquors cause much flatulent distension and uneasiness at the stomach in persons of weak digestive power, and this is owing to the heat of the stomach re-exciting the fermentive action, and causing an evolution of carbonic acid. Dr. Beaumont had an opportunity of observing fermentation, probably of this nature, in the stomach of St. Martin after he had been in the woods all day, and had eaten nothing but whortleberries from seven in the morning to eight in the evening. On looking into the stomach it was

found full of berries and chymefying aliment, frothing and foaming like fermenting beer or cider.

We know that several kinds of *acid* fermentation occur in the stomach, acidity after meals, especially when certain kinds of food, have been taken, being one of the most common symptoms of indigestion. *Lactic acid*, generated by fermentation of the sugar or starch contained in the food is the most common cause of the acidity, and this kind of fermentation gives rise to less disturbance than any other, one atom of sugar being transformed into two atoms of lactic acid without the evolution of any gas. This acid is also one of those which with pepsin produces an energetic digestive fluid, and it is so commonly present in the gastric juice, that it may in moderate quantity be considered a normal constituent. In excess, however, we have seen that any acid weakens or stops digestion, and it is so with the lactic, whether it be, as some have supposed, a secretion from the stomach, or a product of unnatural fermentive action. This disorder, it has been observed by Dr. Budd, is most common in nervous persons with feeble digestion, in whom it not unfrequently happens that acid collects in great quantity in the stomach after meals. They often familiarly tells us, that almost everything they take turns to an acid. If vomiting occur an hour or two after meals, the matter thrown up is very acid, and on analysis the acidity has been often found to be mainly due to lactic acid. In the case of sarcinic fermentation observed by Professor Goodsir, a considerable quantity of lactic acid was found on analysis by Dr. George Wilson, but the chief acid in that case was the acetic.

There is another kind of acid fermentation which often goes on along with the lactic, viz., the *butyric*, and this, being an acrid, oily acid, causes the heat and burning sensation at the stomach and in the throat, to which the name of heartburn has been given. We

have already noticed the fact that the same conditions which cause lactic fermentation will, at a higher temperature, cause the production of butyric acid. This acid has been several times found in the contents of the stomach, and its occurrence in Dr. Hassall's case of sarcinic vomiting has been already noticed.

It has been observed that decayed cheese is the ferment which most readily causes this kind of fermentation; and as we know that lactate of lime in contact with it yields butyric acid and tartrate of lime, and that tartrate of lime in the same circumstances yields metacetate and acetate of lime, and as we likewise know that the pungency which some kinds of cheese acquire during maturation is due to the formation of butyric acid, and two similar volatile oily acids, the capric and caproic, we have some ground for believing that these acids, which are generated out of the body in the same circumstances, may also be formed in the stomach. The skin is the excreting organ by which butyric and other oily acids are thrown out of the system, and it is probable that the formation in the stomach and digestive organs of some of these acrid, oily matters from abnormal fermentation, is the cause of the boils and other eruptions of the skin which are so well known to derive their origin from unobserved disorders of the stomach and bowels. During butyric fermentation there is an evolution of carbonic acid and hydrogen gases, which is the cause of the flatulent distension of the stomach and bowels so generally experienced by those who suffer from heartburn.

Acetous fermentation is another kind which seems to occur in the stomach, and it has been already remarked, that in Goodsir's case the acetic was the most abundant acid. In the third case of vomiting of sarcina, which I have related at page 45, the vomited matter was distilled for me by Mr. Abraham, and two drachms and

a half of fluid, obtained by the distillation of four ounces, had a vinous odour and a specific gravity of $\cdot 998$, indicating nearly 2 per cent. of alcohol. It was also acid; and as the usual tests did not indicate the presence of hydrochloric acid, we may conclude that the acidity must have been due to the presence of this volatile acid, and that in the case referred to the acetous must have accompanied the vinous fermentation.

We may thus regard it as a matter proved beyond any doubt, that all these kinds of fermentation do occur in the stomach singly, successively, or in combination. Lehmann also states that Frericks convinced himself that the colourless, viscid, ropy masses which are sometimes ejected in abundant quantity in gastric catarrh, possess almost entirely the same properties as the gum-like substances produced by what is called mucous fermentation. He also observes, that it appears to depend, at least in part, on the nature of the mucous secretion in gastric catarrh, whether the fermentation established in the amylacea be of the mucous, lactic, acetic, or butyric variety.

The *saccharine* fermentation, we have seen, occurs during healthy digestion, under the influence of a ferment contained in the salivary and pancreatic fluids; but diabetes is a disease in which the stomach and other digestive organs acquire a morbid power of converting every sort of amylaceous matter, and even other kinds of aliment, into sugar. In the healthy condition there is no sugar found in the urine, and scarcely a trace of it in the blood, for as soon as it is absorbed into the circulation it is under the influence of the alkali and fibrin of the blood rapidly oxidised, being transformed by the oxygen absorbed at the lungs into lactic acid, and then into carbonic acid and water. In diabetes there is not merely the increased production of sugar, but there seems also to be a failure in the

power to oxidise the sugar which is removed by the kidneys, and there is therefore a loss of an important kind of aliment required by the system, and hence the wasting and loss of flesh which sooner or later result from this disease. As there is not only the loss of power to assimilate the sugar, but also a remarkable tendency to the conversion of the food into sugar, it is obvious that there must be two great indications in the treatment of this disease, viz., to prevent the morbid tendency to the formation of sugar, and to promote the oxidation and assimilation of what is formed. The treatment of diabetes is too extensive a subject for us to enter upon fully here, and I would therefore only now observe, that in carrying out the first indication the attention of medical men has been chiefly directed to the use of those kinds of food which are least prone to undergo the saccharine change; but in examining the long list of remedies which have been found of use in this intractable disease, we find that many of them (and amongst others that might be named creasote) have antifermentive properties, and it is probable that if the attention of medical men were more systematically directed to this object, and to the employment of antifermentive agents, our treatment of the disease would be improved and advanced. Astringents, both vegetable and mineral, have been found of use in the treatment of diabetes, and they, as well as opium, act probably by diminishing the mucous or albuminous ferment. The sulphite of soda appeared to be of service in one case in which I prescribed it, but it has failed in other cases, both in my practice and that of other medical men.

The food also sometimes undergoes the *putrefactive* change in the stomach, causing eructation of offensive smelling gas, which is sulphuretted hydrogen. This disorder is most apt to occur in children who have

eaten largely of varieties of food, and it causes much uneasiness at the stomach, as well as headache and constitutional disturbance, which may be remedied in the most speedy manner by getting rid of the offending matter by means of an emetic, followed by an aperient.

Fermentive Actions in the Bowels.—The tendency to fermentive action does not entirely cease after the food has passed through the pylorus into the intestines. It has been already stated that the digestion of the food is not entirely completed in the stomach, and that a process of solution still goes on in the bowels through the solvent action of the mucus of the gland follicles. There are in the bowels all the conditions which cause fermentive actions, and we know that such actions do occur and are a very frequent cause of pain, flatulent colic, and diarrhœa. The bile is, however, an anti-fermentive agent, and, like the gastric juice, it has, when in its natural healthy state, the power of controlling or preventing the tendency to unnatural fermentive actions in the bowels.

The fermentive actions which occur in the bowels are, no doubt, of the same nature as those which take place in the stomach. In the upper part of the intestinal canal, the duodenum and jejunum, the contents are always acid, deriving this quality from the acids of the stomach. In the ileum the acid begins to diminish, and disappears before we reach the cœcum. As a general rule, the contents of the large intestine are alkaline; but whilst the part nearest the mucous coat is alkaline, the inner contents may be acid. The acid reaction is usually dependent on the presence of lactic acid, but occasionally on that of butyric acid, or acetic acid. These acids are produced from starchy or saccharine kinds of food, by the same fermentive actions by which we have seen that they are generated in the

stomach. During butyric fermentation we have observed that hydrogen gas is evolved, which causes flatulent distension, and also gives rise to the production of sulphuretted hydrogen, and the acid itself causes uneasy sensations in the bowels, or colic, and even sometimes spasmodic obstruction of the bowels. The irritation from these acids may also cause increased secretion from the mucous membrane and diarrhœa; and we know that the morbid matters generated by such fermentive actions are, especially in children and weak persons, the cause of intestinal disorders, accompanied with fever and constitutional disturbance, or with vomiting and purging. Calomel, mercury with chalk, and magnesia, are favourite remedies in the treatment of such disorders in children; and it is worthy of notice that calomel acts not merely as a purgative in removing the irritating matters and promoting a flow of healthy bile, the absence of which is often the cause of the abnormal fermentation, but it also acts itself as a direct antifermentive agent*, my experiments having proved that mercury is one of the most active of these chemical agents. The chalk and magnesia are of service by combining with the acids, and neutralising their acrid properties.

The diarrhœa and attacks of English cholera which occur so frequently in autumn are undoubtedly due in many cases to fermentive actions exerted in the bowels by the use of fruit and articles of food prone to undergo acid fermentive changes.

When the irritation from fermentation in the bowels causes spasm and obstruction of the bowels, the symptoms are often more severe and dangerous than when it leads to the opposite effect, and the following is a case in which most obstinate obstruction of the bowels ap-

* See page 29.

peared to be produced by an active kind of fermentation:—

On the 25th October, 1855, I was requested to see, in consultation with her ordinary medical attendant, Mrs. T., aged 24, a stout married lady, of costive habit, who had been ill a week with obstinate constipation and vomiting. The pain in the bowels was very severe, but of remittent character, and during the paroxysms she screamed and writhed very much. Before I saw her she had been bled from the arm, and with leeches; she had taken active purgatives, and had used injections repeatedly. Small doses of calomel with opium had also been given, but all these means had failed in affording the least relief, and the pain and vomiting were very urgent. I prescribed a full dose of calomel, ten grains with one grain and a half of opium, which stopped the vomiting, though it did not move the bowels; the stomach being then in a condition to retain aperient medicine, a pill containing aloes, inspissated ox-gall, hyoscyamus, and oil of caraway, was given every second hour; and at stated intervals an injection with turpentine and castor oil was administered. On the morning of the third day the bowels were freely opened, and it was observed that the first copious motion was in a state of active fermentation, and the surface of the fluid in the vessel was covered with a brown frothy head. The patient was completely relieved, and soon got quite well.

There can be no doubt that in this case some acrid matter, probably of an acid nature, had been generated by fermentation, and had induced spasm and obstruction of the bowels, as there were no scybulous masses in the motions to which it could be attributed. It may not be unworthy of remark here that turpentine, which so often affords relief in flatulent states of the bowels, and in colic, has a powerful effect in stopping fermentive actions, and also that assafetida, which is sometimes

used for the same purpose, has likewise antifermentive properties.

Fermentive Actions in other than the digestive Organs.

— Having now examined the fermentive actions which occur in the stomach and intestinal canal, and having seen how much these actions are influenced by the condition of the mucous secretions, and in the stomach by the condition likewise of the chief outlet, we shall now, in connection with them, briefly advert to some fermentive actions which occur in another mucous cavity, and are of somewhat analogous nature in this respect, that like those of the stomach, they are influenced both by the state of the mucous secretion and the outlet of the organ.

The urine, it is well known, undergoes two kinds of fermentation, viz., the acid, and the alkaline, urinary fermentation. The urine is usually acid, but it may be rendered alkaline at the time it is voided by the use of acetate or tartrate of potass, and when it has thus been rendered alkaline it becomes, after a certain time, acid in consequence of the acid fermentation which causes the precipitation of urate of soda and uric acid. This species of fermentation is produced by the mucus of the bladder acting as a ferment upon the extractive pigment, and causing its metamorphosis into lactic acid. This fermentation may also be impeded or stopped by most of the conditions which in other cases obstruct fermentive actions, by the addition of a little alcohol, by boiling the urine, or even by removing the mucus by filtration. Lehmann also thinks that the oxalate of lime, which is not present in fresh urine, but is thrown down as a sediment after a time, may be formed, or at all events separated, during this process of fermentation.

The duration of the acid fermentation extends to four or five days, and it is succeeded by the alkaline variety.

The latter, however, may be at once rapidly induced by a small quantity of alkaline urine, from which it has been concluded that in this, as in other kinds of fermentation, there is a special alkaline ferment which is due to the changed urinary mucus.

The alkaline fermentation of the urine by which the uræa is decomposed, and carbonate of ammonia formed, may, in morbid states, occur even in the bladder itself, and the conditions, under which it takes place, bear some analogy to those in which we have seen that fermentive actions are induced in the stomach. Thus, in catarrh of the bladder, the increased and altered secretion of mucus causes rapid alkaline fermentation, sometimes, even in the bladder itself, producing a deposit of phosphates. As we have seen that organic stricture of the pylorus causes active fermentation in the food, so we also find that prolonged retention of the urine in the bladder, either from paralysis or from a stricture, or other obstacle to its excretion, produces alkaline fermentation, and the incomplete evacuation of the bladder seems to leave behind a ferment which keeps up and renews the fermentation, just as we have reason to believe that the acids and germs of *sarcinæ* which remain in the stomach, in cases of stricture of the pylorus, re-excite the same actions again in fresh quantities of food taken into the stomach.

It is commonly believed that the formation of gravel and calculi in the bladder depends almost entirely on the qualities of the urine, and the solid matters it holds in solution. Sherer has, however, endeavoured to show that processes of fermentation which occur within the bladder under the influence of the mucous secretion contribute largely towards the formation of calculi, and this view of the subject is certainly deserving of attention, the different diatheses, lactic, uric, and phosphatic, having hitherto engrossed attention too exclusively.

In treating, therefore, a case in which there is a deposit of sand in the urine, we should not lose sight of the fact that it may result from a double cause, or rather from the same cause acting on two organs or mucous surfaces at once. Thus, the same disturbing influence may induce a catarrhal state of the stomach and of the bladder, the condition of the former altering the natural ingredients of the urine and their proportions, and that of the latter causing fermentive actions by which the deposit may be thrown down. A remedy which acts on one mucous surface has generally a more extended effect, and acts more or less on all the others; and we should not lose sight of the effect that a remedy, given to improve digestion, may directly produce by its action on the mucous surface of the bladder. I may illustrate this more clearly by referring to a case lately under my care, in which this principle was kept in view in the treatment.

A healthy looking man, 50 years of age, consulted me on account of general debility, with great depression of spirits and nervousness. There was loss of appetite and indigestion, and he complained very much of weakness and pain in the back and loins. The urine was alkaline, and there was a deposit which, on microscopic examination, was found to consist of phosphates. He was first treated with nitro-muriatic acid given in infusion of buchu, the object in giving the acid being more particularly to strengthen and improve the digestion, for it has been pointed out by Dr. Golding Bird that acids have very little direct effect in diminishing alkalinity of the urine, and the object in giving the buchu being to check mucous secretion in the bladder and kidneys, as well as to improve the tone of the gastric mucous membrane. His health and spirits rapidly improved under this treatment, and after a time the phosphates disappeared, and a few crystals of oxalate of lime were then observed. When

the beneficial effect of these remedies seemed exhausted, gallic acid was prescribed, with a view of strengthening still further the mucous membrane of both the stomach and bladder; and a further amendment took place, but phosphates still occasionally appeared in the urine. Another remedy which also exerts an astringent action on the mucous surfaces, especially those of the stomach and bladder, was now prescribed, viz., the tincture of the sesquichloride of iron, and by it the recovery of the patient was sustained and completed.

Throughout the whole treatment of the case, which lasted two months, the main object kept in view was, the removal of abnormal mucous secretion, and the remedies used for this purpose were such as tended to improve the general health and strength, and such as at the same time exerted an astringent action on the mucous surfaces, selection in the first instance being made of one which is known to have a more direct action on that of the bladder and kidneys.

The various fermentive actions we have examined, though they occur in the interior of the body, are yet in a measure external to it, being outside the circulation. We have reason, however, to believe that actions of a fermentive nature do take place in the living animal economy, in the blood itself, and are the cause of many diseases.

We shall have occasion, when we examine the different kinds of diet with reference to their fermentive tendencies, to observe that some kinds of food acquire, by fermentation, the power of acting as poisonous ferments; that in this way German sausages sometimes produce violent vomiting and purging by the action of the poison on the stomach and bowels, whilst in other cases it is absorbed into the blood, and produces a peculiar kind of slow poisoning effect. It is well known, too, that the entrance of any putrid matter directly

into the blood through a wound produces great constitutional disturbance, often causing putrid fever and death. There can be no doubt that some diseases, which may be introduced by inoculation, such as small-pox, and others of infectious nature, such as measles and scarlet fever, which attack the same individual only once, running a definite course, produce an effect on the blood of fermentive nature; and that their action on the economy is of this nature seems to be sufficiently recognised in the fact that the registrar-general calls them zymotic, or fermentive diseases. It is worthy of notice that the poison or contagion of these diseases is destroyed by the same agents which stop putrefaction and fermentation, and that elevation of temperature to the boiling point, which stops all fermentive actions, destroys also the infectious matter of all diseases. We have seen that there are many antifermentive agents, with the exact effects of which the chemist is but little acquainted, and the properties of which, though they admit of being absorbed into the blood, so as to act on any fermenting matter there, have not been at all examined by medical men in relation to their power of destroying such morbid poisons. I have mentioned the fact that bichloride of mercury is one of the most powerful antifermentive agents, which not only explains how mercurials act in fermentive disorders of the bowels, but may also throw some light on the manner in which mercury, when introduced into the system, acts as the most energetic remedy in eradicating syphilis. The poison of serpents, which causes a rapid septic or putrefactive action, and even gangrene in the part to which it is applied, is probably a ferment of albuminous nature. It is worthy of notice that albuminous substances are not readily absorbed by mucous surfaces, and hence this poison has no bad effect on the mouth, and when received into the stomach, it is

so acted on by the gastric juice that its properties are entirely destroyed.

As my present object is only to examine the fermentive actions which occur in the stomach and intestinal canal, I advert to these facts merely to show that fermentive actions have a much more extended influence on the economy of man than is commonly supposed, and that the whole subject is one of great interest, and deserving of profound investigation in relation to the prevention as well as the treatment of disease.

CHAP. V.

TREATMENT OF DYSPEPTIC DISORDERS. — ACTION OF
REMEDIES.

PAIN AT THE STOMACH. — ITS CAUSES. — VARIETIES AND TREATMENT.
— ACIDITY AND HEARTBURN. — TREATMENT WHEN CAUSED BY FER-
MENTIVE ACTIONS. — WHEN CAUSED BY GOUT. — VOMITING. — ITS
CAUSES. — TREATMENT OF THE VOMITING IN CASES OF PULMONARY
CONSUMPTION. — TREATMENT OF HYSTERICAL AND OTHER FORMS OF
VOMITING. — FLATULENCE. — ITS DEPENDENCE ON FERMENTIVE
ACTIONS. — TREATMENT OF COLIC AND DIARRHŒA FROM FERMENTA-
TION. — ACTION OF REMEDIES USED IN DYSPEPTIC DISORDERS. —
— HOW FAR DUE TO ANTIFERMENTIVE PROPERTIES. — TANNIN. —
GALLIC ACID. — METALLIC ASTRINGENTS. — NITRATE OF SILVER
ASTRINGENT AND ANTIFERMENTIVE. — BISMUTH. — PREPARATIONS OF
IRON. — SULPHATE OF COPPER ANTIFERMENTIVE AND ASTRINGENT.
— PROPERTIES OF ALUM. — ALTERATIVE EFFECTS OF BICHLORIDE OF
MERCURY, ETC. — MINERAL ACIDS. — SEDATIVE PROPERTIES OF
PRUSSIC ACID. — EFFECTS OF ALKALINE REMEDIES. — CREOSOTE
AND WOOD SPIRIT ENERGETIC ANTIFERMENTIVE AGENTS. — PEPSIN. —
IPECACUAN, ETC.

IN investigating the different morbid conditions of the stomach, and the fermentive actions which are produced in this organ and the bowels, we have, as we proceeded, drawn attention to the leading and more obvious indications in respect to the treatment of the dyspeptic disorders which arise from such states. The practical part of our subject would, however, be incomplete if we were to omit a more detailed examination of the treatment; and as some of the chief symptoms of dyspeptic disorders not unfrequently assume the prominence of distinct diseases, and demand the exercise of all our penetration and practical sagacity in search-

ing out the true cause, and in devising the best means for their removal or palliation, we shall now proceed to point out the treatment necessary for the symptoms referred to, and to show how far the previous investigations tend to throw light upon this subject, and upon the action of certain antifermentive remedies.

The most important of the symptoms which occur in disorders of the stomach and bowels are pain, acidity, heartburn, sickness and vomiting, flatulence, constipation, colic, and diarrhoea. The severity of these symptoms varies very much. They may all occur as the effect of fermentive actions, but we also know that they are produced by other causes. In examining the treatment necessary for each of them, we shall do so with the view more particularly of pointing out the indications which arise out of their frequent dependence on abnormal fermentive actions.

Pain is a symptom which is seldom absent when there is cancer, or other organic disease of the stomach; but in connection with the sarcinic fermentation, which so often accompanies these states, we have already pointed out the treatment.

Simple ulcer of the stomach is sometimes met with, where no pain has been experienced till it has been suddenly produced by perforation, and a case of this kind came under my observation, where a stout young woman was suddenly seized with intense pain from this cause while walking up stairs. In most cases, however, of this disease of the stomach there is more or less pain previously, which is experienced chiefly after eating, and while digestion is going on. The regulation of the diet, and the use of the mildest kinds of nutritious food, are of the utmost importance here. Some metallic astringents, which are useful in external ulcers, promote likewise the healing of gastric ulcers. Bismuth

may be given with magnesia where there is acidity, and nitrate of silver is often useful in allaying the pain; but the preparations of iron produce not only a beneficial local, but also a constitutional action by removing the anæmic or cachectic condition which is so often the cause of these ulcers of the stomach.

The pain which occurs towards the conclusion of digestion, when the stomach is empty or nearly so, arises very often from imperfect digestion and fermentive actions generating acids. Alkalis, with prussic acid in a tonic bitter infusion, most frequently relieve this kind of pain, and magnesia with bismuth is often of service. But at the same time the secretions of the liver and bowels should be promoted by suitable aperients, and the diet should be such as admits of easy and perfect digestion. The pain which arises from spasm is often most speedily removed by the carminative essential oils, or by aromatic spirit of ammonia; and when these fail, by opium or morphia.

Severe and frequently recurring pain at the stomach is a more frequent symptom in females than in men, and in them is often connected with irregularity of the uterine functions, and a pale chlorotic condition with languid circulation. In these cases I have found carbonate of ammonia or the fixed alkalis, with prussic acid in bitter tonic infusions, of most use in the first instance, and afterwards the preparations of steel. In cases where the irritability of the stomach has been greater, I have succeeded with creosote and the nitrate of silver.

Acidity and Heartburn.—Independent of acidity arising from the acids which are taken with the food, it would seem that an excess of acid may occur in the stomach from two causes,—from the generation of the various acids which we have already seen to be produced by fermentive actions, and also from an excessive secre-

tion of acid by the stomach itself. We have pointed out that hydrochloric acid is a normal constituent of the gastric juice, and that this acid and the lactic are the only acids which, with pepsin, produce powerful digestive solvents. Lactic acid is present in the juice of the muscles, and it is probable that it is secreted by the stomach; but whether or not, there can be no doubt that it is much more frequently generated in excess, by the fermentation of the saccharine and amylaceous portions of the food. We have seen that the other acid which is generated in this way is the butyric, and that both of these are a common cause of pain, heat, uneasy digestion, and a sinking sensation at the stomach, the butyric and probably other oily acids of the same series being more particularly the cause of heartburn.

The acidity which is produced by excessive secretion of acid is most common in persons who suffer from gout or the dyspeptic disorders which precede it, and this form of acid dyspepsia occurs generally in persons past the middle period of life, who have often lived freely, and in whom the secondary assimilating processes are chiefly deranged. These derangements have a tendency to poison the blood; and we have positive evidence, from chemical analysis of this fluid in persons affected with gout, that in this disease uric acid which should either be consumed by more perfect oxygenation, or which should be thrown out by the kidneys, is retained in the blood, and produces the disease. The presence of such morbid matter in the blood arises chiefly from either defective action of the secreting organs, more particularly the kidneys and liver, or from too much and too stimulating food being used, in proportion to the bodily requirements and the amount of active exercise taken by the individual.

The treatment of acidity and heartburn must be different, according as they proceed from the first or the

second of these causes. When the acidity and heart-burn arise from fermentive actions, our attention must be directed, not merely to the neutralisation of the acid acrid matters which irritate the stomach, and to the stoppage of the fermentive actions by antifermentive agents, but also to the removal of those morbid states of the mucous membrane which we have shown to predispose to fermentive actions by producing increased secretion of mucus. Alkaline remedies, which both neutralise acidity and stop fermentation, generally afford, in conjunction with bitter tonics, the quickest relief; after which, some of the more astringent metallic tonics, such as the tincture of the muriate of iron, or the sulphate, or one of the mineral acids, should be given in a bitter infusion to improve more permanently the tone of the mucous membrane. The combination of bismuth with magnesia fulfils the same indications, and is one very commonly prescribed in the treatment of heart-burn and acidity. We have shown that congestion of the liver tends to induce a similar state of the gastric mucous membrane, which is one of those conditions that produce fermentive disorders; and this shows the necessity of exciting in such cases increased activity of the functions of the liver, by which we may also remove the congestion of the stomach. Hence the utility of giving aperients, with which blue pill or calomel is combined, in these disorders, whilst we at the same time strengthen the stomach by tonics. I would, however, again notice the fact that in giving any mercurial preparation we make use of a remedy which is itself an active antifermentive agent; and I would also observe that the well-known alterative effects of bichloride of mercury, given in minute doses with tincture of bark, may be due to its antifermentive properties.

We have seen that there is a certain medium proportion of acid most conducive to rapid and perfect diges-

tion. In cases of excessive acidity, the power of digestion being thus weakened, it is important that it should not be overtaxed, and the food should therefore be light, and so regulated that it may be perfectly digested, these fermentive disorders being often induced, even in those who have good powers of digestion, by neglect of this obviously important rule.

The acidity and heartburn which arise from gout require a somewhat different plan of treatment, and the chief indications should consist in the prevention and removal of the morbid state of the blood. Alkaline remedies, more particularly potash and magnesia, exercise, not merely a palliative action by neutralising acid, but also an eliminative action on the kidneys and liver, which renders them even more important remedies in this form of acid dyspepsia. The excreting functions of these organs should be still further promoted by colchicum and blue pill, and by saline aperients. In both of these forms of acid disorder, fermented liquors should be avoided, as well as the sweet and the acid wines; such an amount of exercise should be taken as may suit the individual case, and best promote the healthy action of the stomach and various excreting organs; the maintenance of a cheerful state of mind should not be overlooked; and the diet should be light and rather sparing, with a due proportion of farinaceous and animal food, avoiding the use of subacid fruits.

Vomiting. — There are few medical men who have not met with cases of vomiting where this symptom has not assumed all the prominence of a separate disease. It may arise from a great variety of causes, not only from conditions of the stomach itself, but also from disordered states and diseases of various other organs of the body. The vomiting which arises from the sympathy between the stomach and other organs

is often more severe and uncontrollable than that which is produced by organic disease of the stomach itself. Sea-sickness, produced through the medium of the nervous system, is an example of this. Vomiting may be produced, independent of any gastric disease, by injuries of the brain, and it is a common symptom of inflammation of the membranes of the brain. It may occur from inflammation or disease of any of the abdominal organs, and it is frequently met with as a consequence of disease of the kidneys and of the liver; and calculi in the ureters, or the ducts of these important organs sometimes cause very obstinate vomiting. It is well known that during pregnancy, as well as in various other states of the uterus, the sympathy between the stomach and this organ causes vomiting. We have it also in all obstructions of the bowels which stop the peristaltic action, and likewise in tubercular peritonitis. In consumption, vomiting, in conjunction with other gastric symptoms, sometimes assumes greater prominence than the symptoms of the pulmonary disease itself. Having already treated so fully of the vomiting from sarcina, and the most suitable remedies, I shall confine my remarks on the treatment of vomiting to its occurrence in conjunction with three diseases, viz., pulmonary consumption, hysteria, and constipation. Vomiting occurs sometimes in consumption simply from the violence of the cough, causing the expulsion of the contents of the stomach, just as happens in hooping-cough, from a kind of spasmodic action of the diaphragm and other muscles. In such cases the vomiting does not arise from any gastric disorder, and can be relieved only by such remedies as lessen the violence of the cough. In other cases the vomiting is accompanied with loss of appetite, nausea, redness at the tip of the tongue, and other dyspeptic symptoms, which show that there is an inflammatory

or congested condition of the mucous membrane of the stomach, and for which, if there be a loaded state of the tongue or constipation, alterative mercurial aperients may be required. Dr. Budd states that after death in such cases the mucous membrane is often found softened, thin, and even dissolved; and he thinks that such appearances, which were so often observed by Louis, are produced not by any direct effect of the tubercular or constitutional disease on the stomach, but by sympathetic disorder and untimely secretion of gastric juice excited by reflex nervous influence. He considers the softening a post mortem appearance, caused by undue secretion of gastric juice; and taking this view of the disorder, he recommends antacids and vegetable astringents, or chalk mixture. I have had occasion to treat many most severe cases of vomiting in consumptive cases, and my observation leads me to take a different view of the dyspeptic disorders and vomiting which so often accompany this disease. We see no such well marked sympathy between the stomach and the lungs in other pulmonary diseases, and it is certainly not from any sympathy between the lungs and the bowels that we see tubercles simultaneously deposited in the mucous follicles of the intestines and in the lungs.

I regard the gastric disorder as a primary derangement, and the vomiting as much the independent effect of the tubercular diathesis affecting the stomach, as the ulcers and deposits of tubercle in the follicles of the intestines are the independent effect of the tubercular diathesis. When vomiting occurs, too, it very often, but not always, goes along with diarrhœa, and in its severity bears a much closer relation to this symptom than to either the cough or the extent of pulmonary disease. As regards treatment, I have found pyroacetic, or wood spirit, creosote, and tar water, the best remedies in this

form of sickness and vomiting. It is not known how these remedies act, but I would observe that all of them check mucous secretion, and that they are active antifermentive agents; on the other hand, I have tried the sulphite of soda in some of these cases, and have not found it of the slightest use. In those cases of consumption where the vomiting is accompanied with diarrhœa, it is often a more obstinate and uncontrollable affection. Nitrate of silver is sometimes of use, but I have found a combination of bismuth with gallic acid and opium answer the best. In the case of a lady who had obstinate vomiting and diarrhœa, with tubercular disease of the lungs, and who had the additional complication of renal disease, causing dropsy, the vomiting and diarrhœa were for a time effectually checked, and great relief afforded by this combination. I also used the same combination in the case of a gentleman who had the same symptoms with a minute trace of albumen in the urine, and it proved of great service in relieving the irritability of the stomach after a variety of other means had failed. The removal of the irritability of the stomach, and the dyspeptic disorders which so commonly occur in pulmonary consumption, is a matter of the first importance in the treatment of a disease which is primarily undoubtedly one of disordered nutrition.

Hysterical or nervous vomiting is one of the most troublesome forms of this disorder to remove. When the ordinary sedative means have failed, I have seen the application of a blister succeed. Such means were of no avail in the case of a lady under my care, in whom the application of a blister at once had the desired effect. Dr. Abercrombie states that he had known some very protracted cases yield to the use of a strong tincture of garlic, and some which had resisted much treatment yield to the practice of keeping up a slight

but continued action on the bowels by very small doses of laxatives, repeated at short intervals. The keeping of the bowels open is an important point, which should never be lost sight of, more especially in hysterical vomiting. Acting upon this rule in a case of obstinate hysterical vomiting in a young woman for whom a variety of means had been unsuccessfully tried, I gave a grain of aloes three times a day, with the effect of speedily stopping the vomiting.

The vomiting of obstinate constipation can only be stopped by restoring the downward peristaltic action of the bowels. A large dose of calomel, with one or two grains of opium, is one of the best remedies both for checking sickness and moving the bowels, and it should be followed up by small and frequent doses of aloes and hyoscyamus, to which inspissated ox-gall may be added with advantage. These means, aided by injections, have usually succeeded in my practice; and in some where they have not, and where I have had reason to believe that there was spasm, I have tried the tobacco enema, and have succeeded in moving the bowels, when other means had failed. In the most obstinate case in which I have ever seen recovery take place, one in which all these means had failed, and in which there had been stercoraceous vomiting for seven days, I have reason to believe that the application of galvanism, by restoring the downward peristaltic action, was the means of saving the patient's life. The patient was a woman of bilious temperament and costive habit, whom I attended in consultation with Mr. Hannah. Galvanism was very effectually applied to the bowels and the back at 10 o'clock in the evening, the vomiting entirely ceased during the night; and at noon the next day the bowels began to be freely moved. In another obstinate case which I attended with Mr. Byerley, where there was reason to believe that there was some organic stricture

in the sigmoid flexure of the colon, galvanism was also used with partial success, the bowels having been moved by it, though the symptoms afterwards returned, so that the patient ultimately sunk. From what I observed, however, in these two cases, I would strongly urge the use of galvanism in ileus, where we have reason to believe that it arises from partial loss of power of the muscular coat of the bowels.

There is one other kind of vomiting which I would still notice — that form of it which is not unfrequently met with in persons who have been indulging in such a continued use of spirituous liquor as leads to delirium tremens. In this form of vomiting, which arises from gastric irritation, with probably an aphthous state of the mucous membrane, we should place our chief reliance on opium, and it should be combined with calomel, to promote the biliary and other secretions, and followed by the use of saline and aperient medicines, which may tend to remove inflammatory action, and that aphthous condition of the mucous membrane, which was seen by Dr. Beaumont in the stomach of St. Martin, after a course of intemperate living.

Flatulence. — Flatulent distension of the stomach or bowels may arise in some instances from air being swallowed, and there is always mixed with the saliva some atmospheric air, which appears to have some special use in promoting digestion. It is not improbable, too, that the mucous membrane of the stomach may have the power of secreting some gases, such as nitrogen and carbonic acid; but there can be no doubt that when gaseous distension occurs to any considerable extent, morbid fermentive action is the most common cause. Vinous fermentation causes an evolution of carbonic acid, the stimulating property of which produces its expulsion from the stomach. We have seen that lactic fermentation does not produce any gas, but butyric fermenta-

tion causes an evolution of hydrogen and carbonic acid gases; and this fermentive action I believe to be the most common cause of the flatulence from which dyspeptics so often suffer. This kind of fermentation occurs both in the stomach and bowels, and we have already seen that butyric acid has been found in the large intestines as well as in the stomach.

Putrefactive fermentation causes the generation of sulphuretted hydrogen, azote, and carburetted hydrogen, and we have seen that it may occur and produce these gases in the stomach, though more frequently in the bowels. It has been proved that the bile acts as an antiseptic in preventing this as well as other fermentive actions in the bowels, and most medical men must have observed how common it is for patients suffering from jaundice to have troublesome distension of the bowels, caused by fermentive actions, which are controlled by a proper secretion of healthy bile.

Loss of vital power is one of the causes of flatulent distension of the bowels, and it seems to arise from fermentive actions occurring in consequence of chemical affinities gaining undue ascendancy from the vital actions being weakened; and hence in typhus, and the last stage of many diseases, we observe tympanitic distension of the bowels.

The flatulence arising from butyric fermentation may be relieved by ammonia and aromatic carminatives, such as spirit of aniseed, but it can be permanently removed only by pursuing the treatment suited to the form of dyspepsia with which this kind of fermentive action is allied. The sulphite of soda and creosote have sometimes proved useful in this disorder by checking the fermentive action, and it is probable that assafœtida relieves flatulence by acting in a similar manner.

Constipation, Colic, Diarrhœa. — All the preceding

facts which have been brought forward with respect to fermentive disorders of the stomach and bowels, tend to establish the importance of the attention so commonly paid to the regularity of the function of the bowels. All fermentive actions are apt to produce unnatural matters of acid or acrid nature in the bowels; and we have also seen that any deviation from the natural qualities of the mucous secretions of the stomach and bowels tends to cause these actions, whilst, on the other hand, deficiency of the bile, by removing the natural controlling power, has a similar effect. There are, therefore, three indications for the use of aperient remedies in the treatment of these disorders: viz., the removal of morbid matters generated by fermentation, which are often the cause of uneasy sensations, colic, and even diarrhœa, which is nature's mode of curing many disorders of the stomach and bowels; an alteration of the quality of the intestinal mucous secretions; and the promotion of healthy biliary secretion. These indications, we have observed, are more effectually carried out by means of mild mercurials than by any other class of remedies; and experience having so amply proved their utility when assisted by other aperients, we have in these researches obtained some insight into the cause of their having been so extensively employed.

We have seen that the ordinary diarrhœa of autumn is undoubtedly often the effect of fermentive actions, excited by the use of acid or unripe fruit, along with other indigestible kinds of food prone to ferment. Here we find no mode of treatment so generally efficacious as the employment of small doses of calomel with opium, by which the pain and the morbid secretion of mucus are both stopped, whilst the calomel promotes the flow of bile. We follow up this, however, by some aperient, such as castor oil, to remove the morbid matters accumulated; and if after this the mucous membrane has

become morbidly relaxed, we give chalk, which absorbs acids, and at the same time acts as an astringent on the mucous surface. In more protracted cases we have recourse to still stronger astringents of vegetable or metallic nature.

Remedies used in the Treatment of Dyspeptic Disorders.

In examining the action and effects of some of the remedies which have been found most useful in the treatment of dyspepsia, we shall have an opportunity of making some further observations on the treatment, and of inquiring how far they act by arresting fermentive action.

We have seen that the chemical agents which completely arrest the vinous fermentation are the bichloride of mercury, the nitrate of silver, the sulphate of copper, the chromate of potass, prussic acid, carbonate of soda, mustard, wood spirit, and creosote: we have also seen that it is weakened by turpentine, assafœtida, and chloride of lime; and we have also observed that the lactic fermentation appeared to be weakened by the sulphite of soda. The facts which have been stated in the second chapter with reference to the antifermentive properties of these and other chemical agents, should not be lost sight of in any investigations that may be made into the action of remedies in dyspeptic disorders.

Tannin is an astringent vegetable principle, which, in its pure state, has not yet been much employed medicinally in the treatment of dyspeptic disorders; but many of the astringent remedies used in disorders of the stomach and bowels owe their properties to this substance. By combining with some albuminous ferments it acts as an antifermentive agent, and in this way it stops the mucous fermentation which occurs in some

kinds of wine, and which there is some reason to believe may occur in the stomach. Dr. Handfield Jones has published in his work several cases of dyspeptic disorder in which he seems to have found this an efficient remedy. I have myself, in treating disorders of the stomach and bowels requiring such an astringent, more frequently prescribed gallic acid, which has similar properties; with this advantage, that it does not cause any sickness when the stomach is in an irritable condition. Tannin is the chief astringent matter in many of the remedies used in those conditions of relaxation of the stomach and bowels with increased mucous secretion, which we have seen to be so liable to cause fermentive actions. Kino, catechu, and krameria, remedies so useful in some cases of waterbrash, owe their astringent virtues to tannin, whilst the properties of uva ursi, which acts as much on the kidneys and bladder as on the mucous membrane of the stomach, are due to gallic acid. Tannin is also present along with bitter principles in some of the vegetable tonic remedies, such as cinchona bark.

I am not aware that the pure bitter vegetable tonics, such as quassia, have any antifermentive action, or produce any other effect beyond the improvement of the tone of the stomach. Hop, however, in the form of infusion and tincture, is a remedy which has been used to a considerable extent in dyspepsia, both to improve the appetite by its bitter tonic properties, and to allay pain by its narcotic action. The effect which hops have upon beer is to give it not only an aromatic bitter taste and soothing narcotic properties, but also a keeping quality, by counteracting its natural tendency to become sour. This is due partly to the precipitation of the albumen and starch by the resinous and tannin constituents, and partly to the antifermentive properties of the bitter principle, volatile oil, and resin contained more

particularly in the lupuline. The hop having these antifermentive properties, and no bitter plant having yet been found which can be substituted for it with advantage in the preparation of beer, we can perceive that there are other reasons, beyond the practical one drawn from experience, for the reliance which some medical men have placed on it as a remedy; and we have reason, from the foregoing facts, to believe that its beneficial effects in some cases of dyspepsia may be due, not only to its tonic and anodyne, but also to its antifermentive properties.

Amongst remedies used in the treatment of dyspepsia and disorders of the bowels there is no class more important than the salts of the metals, which are generally more or less astringent. Of these the nitrate of silver, the subnitrate of bismuth, the sulphate of iron, the sulphate of copper, and alum, are deserving of some notice here, both on account of their acknowledged value in the treatment of these disorders, and their properties as antifermentive agents.

The valuable properties of *nitrate of silver* in the treatment of those disorders of the stomach attended with pain, vomiting, or increased mucous secretion, have been already noticed, and therefore scarcely require further examination. We have seen that nitrate of silver is one of the most active antifermentive agents; and from what we know of its effects when applied to the visible mucous surfaces, where it acts as an astringent and promotes the healing of ulcers, we should expect it to be of service in catarrhal relaxed states, or where ulceration existed; and this being also what practical experience tells us it effects in morbid states of the stomach and bowels, we may ascribe its beneficial operation to its antifermentive and its astringent qualities.

Bismuth is also an astringent remedy which is mild and sedative in its action, and there is none more generally used in the treatment of pyrosis and painful digestion. It is, however, given in dyspeptic disorders without due discrimination, and hence medical men are not unfrequently disappointed in its effects. Dr. Budd has observed that it is of no use in that extensive class of dyspeptic cases where there is a deficiency of gastric secretion. I have already remarked that, in combination with opium and another astringent, gallic acid, I have found it a most valuable remedy in the diarrhœa and vomiting of pulmonary consumption. I made trial of the effect of bismuth on the vinous fermentation, but found that it had no influence whatever upon it. This is only what we should expect, seeing that it is an insoluble substance; but we should not from this fact infer that it may not have the power of repressing fermentive disorder in the stomach, as it is probably rendered soluble to some extent by the acids of the gastric juice.

The preparations of cerium, which have been recommended by Dr. Simpson, are similar in their properties to the nitrate of silver and bismuth. They have been recommended by him more particularly to relieve the sickness and vomiting of pregnancy; and I may state that I have given the nitrate of cerium in several cases of pain at the stomach and vomiting with decided benefit.

It has been already pointed out that the preparations of *iron* have, besides astringent properties, an effect on the blood by their absorption into it; and where our object is to remove an anæmic state of the blood, we should use the milder and less astringent, such as the citrate, till the stomach can bear the more powerful and astringent salts, such as the sulphate.

The sulphate of copper is the most powerful of the mineral astringents in checking mucous secretion, and it has been found an efficacious remedy in ulceration of the bowels from chronic dysentery. It irritates the stomach, however; and though often useful in the diarrhœa of phthisis, caution is necessary in the employment of it in this disease, even in small doses combined with opium, as it is apt to excite vomiting.

Alum is a remedy which has scarcely received the attention it deserves in the treatment of disorders of the stomach. We know, however, that it is very efficacious in checking mucous secretion; and, being a perfectly harmless remedy, it may be introduced into the stomach in much larger doses than most of the metallic astringents. I use it very freely in the treatment of hæmoptysis and hæmatemesis, finding it very superior to the acetate of lead, and devoid of the troublesome constipating effects of the latter. I have observed that it often produces a decided improvement in the appetite and digestive powers; and I observed this particularly in the case of a gentleman from the Isle of Man, who placed himself under my care on account of slight but long continued spitting of blood, and he found his appetite and strength so much improved by it that he continued to take it long after the spitting of blood had ceased.

Now all these metallic salts must, by their astringent action stopping unnatural mucous secretion, have some power in preventing fermentive actions; but some of them, more particularly nitrate of silver and sulphate of copper, have a direct antifermentive power. Alum, we have seen, increases the activity of the vinous fermentation, but it stops mucous fermentation by precipitating the ferment; and sulphate of copper has been found by experiment to stand next to bichloride

of mercury in power as a chemical agent in preventing the decay of wood.

There are several metallic salts which in certain diseases produce effects not fully understood, which we call alterative; and I have already suggested the possibility that the beneficial effects of the bichloride of mercury in minute doses may be due to its anti-fermentive properties, its power of arresting the formation of morbid matter in the intestinal canal, or even of destroying a morbid poison in the blood; and the same view may be taken of the power which nitrate of silver and sulphate of copper are known to have in curing some cases of epilepsy, and of the power which small doses of arsenic (a remedy which alters the mucous secretion of the stomach, and is of use in some cases of pyrosis) have in curing many chronic diseases of the skin.

The *mineral acids* are astringent tonic remedies, which are of great use in the treatment of many dyspeptic disorders. The sulphuric acid and the nitro-muriatic acid improve the appetite and digestive power, and they are often of great use in fermentive disorders of the stomach, in consequence, I believe, of their astringent and tonic action, and their anti-fermentive powers. They frequently have the effect of removing acidity and heartburn, instead of adding to the acidity, when they are taken previous to meals. It is also well known that nitro-muriatic acid, when taken regularly for two or three weeks, is the best remedy we can use for the removal of that form of dyspepsia, in which there is a deposit in the urine of crystals of the oxalate of lime, and which is accompanied with nervous debility and depression of spirits. In dyspepsia with sluggish action of the liver I have found great benefit from the use of nitro-muriatic acid; and I am persuaded, from extensive experience in the treatment of tu-

bercular diseases of the lungs, that it greatly promotes the beneficial action of cod-liver oil, the most valuable remedy in all diseases of a scrofulous or tubercular nature. We have seen, in the chapter on the physiology of digestion, that hydrochloric acid is the chief solvent acid of the gastric juice, and also that small quantities of fat assist it in dissolving the food. This being the case, we can readily account for the benefit which we know from experience is so often derived from giving cod-liver oil with nitric and muriatic acids soon after meals. The power which sulphuric acid has of checking diarrhœa I ascribe to its antifermentive properties.

Prussic acid is a sedative remedy of very great utility in gastric disorders, especially in those anæmic cases accompanied with much nervous irritability. In the dyspepsia which occurs in chlorotic females, where there is so often severe pain at the stomach, with eructation or vomiting of the food, it is one of the best remedies in allaying these symptoms, and it may be given with an alkaline carbonate in a bitter infusion, such as that of calumba. By such means the stomach is gradually rendered capable of bearing the stronger chalybeate tonics. Dr. Budd does not recommend its employment in cases of ulcer of the stomach, where he observes that it is apt to increase the pain unless combined with an alkali. I can confirm the observation he also makes as to this remedy being sometimes injurious instead of beneficial in the vomiting which occurs in cases of consumption.

The *Alkaline* remedies which have been used in the treatment of dyspeptic disorders are soda and potash, but with them we may also notice the alkaline earths, magnesia, lime-water, and chalk. The alkalis have antifermentive properties, and we have seen that soda is

one of the agents which most perfectly arrest the vinous fermentation. They act, therefore, not merely by neutralising the acid formed by fermentive actions in the stomach, but also by checking the action itself; and hence, from the immediate relief they afford, they are very much used as domestic remedies. If taken with the food or whilst digestion is going on, they must, unless there be a great excess of acid, weaken digestion by neutralising the natural acid of the gastric juice. On the other hand, both potash and soda are very useful in relieving the heartburn and acidity proceeding from lactic and butyric fermentation which occurs after meals when digestion is nearly completed. This is the proper time for taking these remedies, which are, however, chiefly palliative, and exert no particular influence over the cause of the disorder. The alkalis, being soluble, are entirely neutralised by the acids of the stomach; but magnesia and chalk escape to some extent the action of the gastric acid, and are therefore remedies better suited to relieve the acid disorders which occur in the bowels.

Lime-water is an antifermentive agent and a very valuable remedy in the treatment of dyspepsia with an irritable condition of the stomach, causing the rejection of the food by vomiting. The disagreeable taste of lime-water is scarcely perceived when it is combined with an equal quantity of milk; and this combination of food and medicine constitutes a form of diet, which I have found of use in allaying the vomiting, which occurs in some cases of nervous debility, hysteria, and advanced phthisis. The lime-water not only neutralises acidity like the alkalis, but it also produces an astringent effect on the mucous surface.

Creosote is a remedy of great value in the treatment

of some disorders of the stomach. It frequently relieves pain and stops vomiting ; but either from the taste being nauseous to some persons, or perhaps from being a variable preparation, I have found it also sometimes aggravate sickness. It is one of the remedies I have found most useful in checking the sickness which occurs in pulmonary consumption, and it also relieves the vomiting which accompanies renal disease. It is sometimes useful in checking diarrhœa. We have seen that it is an antifermentive remedy of service in the treatment of sarcinic vomiting, and Dr. Budd recommends it in the treatment of putrefactive fermentation with offensive eructations ; and he states that he has found no remedy so useful for English cholera as pills with opium and creosote. Creosote has a threefold action on the stomach : by its anodyne power, exemplified in its effect in relieving the pain of toothache, it removes some of the painful neuralgic affections of the stomach ; by its antifermentive agency it arrests fermentive actions ; and by the astringent effect which it exerts on the bronchial as well as the gastric mucous membrane, it prevents unnatural mucous secretion. To these three properties, then, we must ascribe its power of improving the appetite and digestion, and stopping pain and vomiting in many dyspeptic disorders.

Alcohol checks fermentation, but *pyroxylic* or *wood spirit* is a much more energetic antifermentive agent. In its action on the mucous membrane of the stomach and lungs it very much resembles creosote, and it has the power of stopping sickness and vomiting in many cases. It is very generally known that in many cases of phthisis with an irritable condition of the stomach, it has the effect of stopping sickness, and improving the appetite and digestive power, and at the same time diminishing expectoration.

It is well known that *Tar* is one of the most powerful antiseptic agents, this property being due not only to the creosote, but to the empyreumatic oils, wood spirit, and other pyrogenic substances it contains. Tar water, though not a very palatable, was long a popular remedy in dyspeptic disorders, and there can be no doubt that its virtues are chiefly those of an antifermentive remedy. A few years ago I recalled attention to its use in pulmonary consumption, and made some observations on its action on the stomach, and its power of rendering this organ more tolerant of cod-liver oil, in cases where this remedy caused sickness or loss of appetite.*

There are some remedies requiring a brief notice, which have been found useful in the form of dyspepsia arising from deficient secretion of gastric juice. Pepsin, ipecacuan, rhubarb, and ginger belong to this class.

Pepsin, the substance to which the solvent power of the gastric juice is due, may be prepared from the stomach of the pig; and, in solution with hydrochloric acid, it forms an artificial digestive fluid capable of dissolving most kinds of food at the temperature of the body. It has therefore been used medicinally in cases of dyspepsia, from deficient secretion of gastric juice, to assist in dissolving the food; and it has been found to effect this object in some cases, and to add materially to the comfort of those persons who from this cause suffer from the slow and imperfect solution of the food in the stomach.

Ipecacuan is a medicine which, in large doses, irritates the stomach, so as to cause vomiting; but in the minute quantity of from half a grain to two grains,

* Report on the Progress of Improvement in the Treatment of Consumption (by the Author), p. 43.

it acts as a stimulant, and increases the secretion of gastric juice, and it has been strongly recommended by Dr. Budd as the best remedy for this purpose.

In concluding these brief remarks on the action of some of the chief remedies used in the treatment of dyspeptic disorders, I would direct attention to one interesting fact, which seems now for the first time to have been brought to light by my researches, and by the experiments noticed in the second chapter, viz., that many of the remedies, which we find most effective in relieving pain at the stomach, and stopping sickness and vomiting, are energetic antifermentive agents. This observation holds true in respect to creosote, which is one of the most powerful remedies in relieving pain at the stomach, and arresting sickness and vomiting; and also in respect to pyroxilic spirit, another energetic antifermentive agent, which, we have seen, stops sickness and vomiting, especially in phthisical cases. I have found that prussic acid, which is one of the remedies most commonly used to allay pain and irritability of the stomach, and vomiting, is a powerful agent in checking vinous fermentation. Nitrate of silver is another antifermentive agent which relieves dyspeptic pain and vomiting. It is well known that lime-water, and the alkalis which have considerable antifermentive power, allay irritability of the stomach and vomiting in many cases; and the sulphite of soda we have seen to be the antifermentive agent which is most effective in stopping the acid vomiting of sarcina. Of the metallic antifermentive agents the salts of mercury seem to be the most energetic; and it is worthy of particular notice, that calomel is given to allay sickness, &c., in a variety of disordered states of the stomach and bowels. We give it in small doses combined with opium to stop the vomiting which so often accompanies the diarrhœa

or cholera of autumn; and on the other hand, when there is vomiting, with obstinate constipation, we give a large dose of calomel, with a pretty full dose of opium, and find, as in the case alluded to at page 95., that there is no remedy or combination more generally effectual in settling the stomach, in frequently moving the bowels, and in enabling the stomach afterwards to retain other medicines.

As so many of the most energetic antifermentive agents, organic as well as metallic, possess these powers, we are naturally led to conclude from these facts that there is a connection between antifermentive power and the power of relieving pain at the stomach, and sickness and vomiting; and we may also regard it as not improbable, that any medicinal agent devoid of irritating properties, which is proved to have energetic antifermentive properties, will also be found to have more or less power in reference to the symptoms noticed.

It is a very just observation, that practical results do not become the permanent property of science or art, but are liable to be displaced until they are referred to correct principles; and if these conclusions be legitimate deductions from the previous researches, such facts must tend to throw light on the action of remedies, and to give greater precision to our treatment of many of the disorders of the stomach and bowels.

CHAP. VI.

ON DIET.

CULINARY PREPARATION OF FOOD. — ITS OBJECTS. — AZOTISED AND NON-AZOTISED ALIMENTARY PRINCIPLES : — 1. ALBUMINOUS ALIMENTS CAPABLE OF ACTING AS FERMENTS : ANIMAL AND VEGETABLE FIBRIN, ALBUMEN, AND CASEIN. — COMBINATION OF ALIMENTARY PRINCIPLES IN MEAT. — FISH. — DIGESTIBILITY OF DIFFERENT SORTS. — EGGS. — CHEESE. — FERMENTIVE CHANGES DURING MATURATION OF CHEESE. — PERNICIOUS EFFECTS OF ALBUMINOUS ALIMENTS WHEN FERMENTING OR DECAYING. — GERMAN SAUSAGES. — POISON GENERATED IN THEM BY FERMENTATION. — OTHER POISONOUS ARTICLES OF FOOD. — INJURIOUS EFFECTS OF THE BITTER ALMOND FERMENT. — BREAD FERMENTED AND UNFERMENTED. — 2. FERMENTABLE ALIMENTS: STARCH.—SUGAR.—THEIR EQUIVALENT VALUE AS ALIMENT.—DISORDERS IN WHICH THEY SHOULD BE AVOIDED.—FAT AND BUTTER. — THEIR IMPORTANCE AS ALIMENT.—THEIR INJURIOUS EFFECTS IN FERMENTIVE DYSPEPSIA WHEN RANCID OR INJURED BY HEAT. — 3. LIQUID ALIMENTS: WATER. — ITS POWER IN INCREASING WASTE OF THE TISSUES. — EFFECTS OF HYDROPATHIC TREATMENT. — TEA.—COFFEE. — THEIR COMPOSITION. — ANTIFERMENTIVE PROPERTIES.—POWER OF DIMINISHING WASTE OF TISSUE. — FERMENTED LIQUORS. — ANTIFERMENTIVE PROPERTY OF PURE SPIRIT. — 4. SEASONING AGENTS: COMMON SALT. — MUSTARD AND HORSE-RADISH ENERGETIC ANTIFERMENTIVE AGENTS. — ANTISCORBUTIC PROPERTIES OF THE CRUCIFEROUS ORDER OF PLANTS. — GARLIC. — SPICES.

It has been very justly observed, that there is no organ of the body over which each individual is able to exercise a more direct and certain influence than the stomach; and for this reason, that we can introduce into it whatever kind of food or drink we please, of digestible or indigestible nature, or even of irritating quality. According, therefore, to our selection of diet we can

produce important effects on our digestive organs, and, through them, on our general health, our comfort, and our aptitude for the ordinary concerns of life; and medical men have constant occasion to observe, that whilst some, by careful attention to these matters, and moderation, prolong life, there are numbers who, by neglect of them, ruin the best constitutions.

One of the chief objects of the art of cookery is to lessen the cohesion of the food, and at the same time to combine the different staminal principles, so that the work to be done by the stomach, in reducing and dissolving the food, may be lightened as far as possible; and the different culinary processes, roasting, boiling, and baking, &c., have all such an effect upon the food, and must be considered preparatory to the solvent action of the stomach. "Of these operations," Dr. Prout observes, "man avails himself, and they constitute the chief means by which he is enabled to be omnivorous; for without such preparation a very large portion of the matters, which he now adopts as food, would be completely indigestible." Fermentation is one of the means used for this purpose, and in the baking of bread we employ this chemical process to prepare the most common and important kind of vegetable aliment, hence called "the staff of life." It is impossible in a single chapter to examine the whole subject of diet, and for details I would refer to Dr. Pereira's treatise; and I would also observe, that in the "Chemistry of Common Life" will be found many interesting facts as to the proportions of the different alimentary principles in various kinds of food, and explanations of the reasons of our combining one kind of alimentary principle with another, and using food containing excess of one principle with another in which it is deficient. Our investigation of the fermentive disorders of the stomach would, however, be obviously incomplete if we were

to omit an examination of the effects of different kinds of food on those disordered states; for we find, as remarked by Liebig, "that to the class of fermentable substances belong all the matters which constitute the various articles of the food of men and animals."

This distinguished chemist pointed out some years ago the important fact, that all the various organic substances used by man and the higher animals as food, belong to one of two classes, — the azotised, or sanguigenous, derived from the vegetable as well as the animal kingdom, which form the tissues of the body, and replace those which are worn out; and the non-azotised, or combustive, such as sugar, starch, fat, and alcoholic liquors, which act chiefly in furnishing food for the lungs, and the support of respiration and animal heat. Another curious fact, which seems also to have been established by him beyond doubt, is this, that though the fibrin, albumen, and casein, which constitute the chief principles of the azotised class of alimentary substances, exist in vegetable as well as animal food, animals have not the power of forming, in their own bodies, any of these azotised alimentary principles. They are primarily derived from the vegetable kingdom, and the digestive organs of animals seem to have merely the power of assimilating what has been already formed by plants, or previously drawn from the vegetable kingdom by some other animal. These views met with considerable opposition when they were first advanced; but that they are essentially correct is now more generally admitted, and we know that there is no material difference in chemical composition between the fibrin of the flesh or the blood of an animal, and the gluten, or vegetable fibrin which is obtained from wheat, or any other vegetable substance in which it exists; or between vegetable and animal albumen, or vegetable and animal casein.

Dr. Prout, taking milk as the model of a perfect kind of food formed by nature to afford complete nourishment to the young of many animals, divided aliments into four classes, viz. the aqueous, the saccharine, the albuminous, and the oleaginous. The most important kinds of aliment may be embraced under these heads, though certainly not all the articles used as food. As our chief object, at present, is to consider diet in relation to the fermentive tendencies of different sorts, we shall find it convenient to arrange our observations under four heads.

1st. On albuminous aliments, both vegetable and animal, which are capable of acting as ferments.

2nd. On saccharine and amylaceous aliments, or those which can be readily made to undergo fermentive actions.

3rd. On liquid aliments, more particularly water, tea, coffee, and alcoholic liquors.

4th. On seasoning agents, or condiments, such as salt, mustard, horse-radish, pepper, &c.

1. The albuminous class of aliments embraces many of the most important kinds of both animal and vegetable food, and to it belong all the sanguigenous azotised aliments which Liebig has shown to be essential for the repair of the worn-out tissues of animals. The blood of all animals contains, in a state of solution, a peculiar animal matter, which coagulates and forms a white fibrous substance. This is fibrin, which goes to form and nourish the muscular fibre of the flesh of the animal, with which it is identical. It forms the principal part of the fleshy portions of animal food, which is well known to be a most nutritious and digestible kind of food, and it constitutes about sixteen per cent. of lean meat.

The white of egg is a very pure form of albumen, another very important alimentary principle which

exists in the serum of the blood, and also forms an important constituent of meat.

The curd or coagulable part of milk, which forms cheese, is the third albuminous alimentary principle derived from the animal kingdom.

The composition of these three alimentary principles is very nearly identical. There is the same proportion of carbon, hydrogen, oxygen, and azote in each; but fibrin and albumen contain also a minute quantity of sulphur and phosphorus; and casein differs from the two first in containing sulphur only.

Gelatine is another alimentary principle allied to the albuminous, and sometimes classed with them, though it differs from them so essentially in composition and nutritive properties that it cannot be strictly considered as one of this class. It contains no sulphur.

It is a singular fact, which was pointed out by Liebig, that the most important vegetable substances used as food contain principles similar in appearance and physical properties, and absolutely identical in chemical composition with those three alimentary principles — fibrin, albumen, and casein. Thus, in wheat and various other kinds of vegetable aliment, we find gluten or vegetable fibrin, which corresponds to the fibrin of the flesh and blood of animals, like it being one of the most nutritive and most easily digested kinds of aliment, and constituting the most nourishing part of bread. In its pure or nearly pure state, gluten is known to us in the form of vermicelli and maccaroni, which are very nutritious.

There exists in many seeds, such as wheat, and in almonds, a soluble alimentary principle, which coagulates when the liquid is boiled. This substance is vegetable albumen. When the clarified juice of nutritious vegetables, such as cauliflower, asparagus, mangelwurz, or turnips, is made to boil, a coagulum is

formed, which it is absolutely impossible to distinguish from the substance which separates as a coagulum, when the serum of blood or the white of an egg, diluted with water, are heated to the boiling point." It is distinguished from vegetable fibrin in being soluble in water, and from vegetable casein in coagulating when heated.

A third vegetable principle, corresponding to the curd of milk, is found in leguminous seeds, such as peas and beans. It may be extracted from the meal by cold water, and kept in solution. When the solution is heated or evaporated a skin forms on its surface, and the addition of an acid causes the formation of a coagulum or curd, just as in milk.

These three vegetable principles are identical in composition with the corresponding animal principles. It would seem, therefore, that they are dissolved and assimilated by the digestive organs of animals without undergoing any material change, and the nutritive value of most kinds of food bears a close relation to the quantity of albuminous principles they contain.

None of these alimentary principles are capable alone, in the pure state, of nourishing the body for any considerable time; and this observation applies to all other pure alimentary principles, such as sugar, starch, gelatine, and fat. For perfect and prolonged nutrition it is necessary that several of them should be combined, as in bread, in which we have saccharine and amylaceous matters, and a minute quantity of oily matter with the gluten; or, still better, as in milk, which contains, in addition to the albuminous curd, the butter and the sugar of milk, as well as certain salts. The flesh of animals, which is also adapted for prolonged nutrition, contains not only fibrin and albumen, but also fatty and gelatinous matters and salts. The gluten of wheat is said to be the only pure alimentary principle which

alone has been found capable of the prolonged nutrition of animals; but even this can sustain life only for a limited time, and it is doubtful if it has been used in a perfectly pure state.

The muscular substance commonly called flesh or meat contains about 15 or 16 per cent. of fibrin, and 3 of albumen, acids, more or less fat, gelatine, extractive matters, and salts. Mutton is generally found to be more easily digested than beef. The flesh of young animals is more tender than that of old ones, and therefore more readily dissolved in the stomach; but this is not always so, for some, such as veal, contain much gelatine, which renders the meat less digestible, and less nutritious than that of the full-grown animal. The white kinds of meat, such as that of fowls, rabbits, and fish, are considered less stimulating than the darker-coloured meats. The dark-coloured flesh of game and wild animals is easily digested, but heating. It contains scarcely any fat, but a considerable quantity of kreatine. In fish there is much albumen, and but little kreatine. The red species, such as salmon, are the least digestible, owing to the quantity of oily matter contained in the flesh. On the other hand, the whiting, the haddock, the sole, the plaice, the flounder, the cod, and the turbot, are nearly devoid of fat or oil, except in the liver, and they have been considered as belonging to a more digestible class.

Eggs consist chiefly of albumen, and are a highly nutritious article, which suits the digestion of most persons. The white of egg is a very pure form of albumen. The yolk is composed of about 20 per cent. of albumen, with about 30 of oily matter in a state of subdivision and mixture, which adapt it well for digestive purposes.

Cheese is one of the albuminous articles of food most deserving of notice in reference to fermentive actions.

It varies, however, very much in its qualities, according to the way in which it has been made, the proportion of butter it contains, and the degree of maturation or decay it has reached. When nearly all the cream or butter has been removed from the curd, it forms the hard, horny, and indigestible kind called "Suffolk bank, which often requires an axe to cut it, and which is so hard that pigs grunt at it, dogs bark at it, but neither of them dare bite it."

Cheese is a very concentrated and highly nutritious kind of food, but it is not easily dissolved in the stomach, and therefore disagrees with many persons. There are some, however, who find that a small piece of ripe or decaying cheese, taken after dinner, promotes the digestive process, and in these persons it probably acts as a kind of ferment. The quantity of butter or oily matter it contains, its age, and the manner in which it has been kept, are all circumstances which exercise an influence on its solubility, its pungency, and its tendency to promote fermentive actions. The changes produced by keeping consist in the generation of various volatile fatty acids which give to it their characteristic odour, and which are most apt to be generated in those kinds in which there is a large proportion of fatty matter. They are thus explained by Liebig:—"When kept in a cool place, a series of transformations take place, in consequence of which it assumes entirely new properties; it gradually becomes semi-transparent, and more or less soft throughout the whole mass; it exhibits a feebly acid reaction, and develops the characteristic caseous odour. Fresh cheese is very sparingly soluble in water, but after having been left to itself for two or three years it becomes, especially if all the fat be previously removed, almost completely soluble in cold water, forming with it a solution, which, like milk, is coagulated by the addition of acetic acid, or

the mineral acids. The cheese which, while fresh, is insoluble, returns during the maturation or ripening, as it is called, to a state similar to that in which it originally existed in the milk. In those English, Dutch, and Swiss cheeses which are nearly inodorous, and in the superior kinds of French cheese, the casein of the milk is present in its unaltered state. The odour and flavour of cheese is owing to the decomposition of the butter, the non-volatile acids, margaric and oleic acid, and the volatile butyric, capric, and caproic acids are liberated in consequence of the decomposition of glycerine. The volatile acids impart to cheese only its characteristic caseous odour, and the differences in its pungency or aromatic flavour depend upon the proportion of free butyric, capric, and caproic acids present. The transition of casein from its soluble into its insoluble state depends upon the decomposition of the phosphate of lime by the margaric acid of the butter; margarate of lime is formed whilst the phosphoric acid combines with the casein, forming a compound soluble in water."

It has been pointed out in a previous chapter that there are certain animal and vegetable substances all derived from azotised bodies, which act as ferments. These substances, which are prone to undergo decomposition, are the same albuminous principles, viz. fibrin, albumen, and casein, which together with gelatine constitute the basis of the articles of diet we have just noticed. We shall now, therefore, proceed to examine some of the kinds of food belonging to this class in relation to their tendency to produce fermentive actions in the stomach.

As there is no kind of aliment capable of nourishing and maintaining the life of any of the higher animals for a considerable time, which does not contain one at least of the azotised alimentary principles, it must

be obvious that the stomach is constantly receiving some of the substances which act as ferments, besides having its own mucous secretion, which has the same property. The azotised substances, however, only act as ferments when they have been brought into a state of change or decomposition, which is arrested by the boiling temperature to which so much of our food is subjected, as well as by the gastric juice which has more or less antifermentive power, especially in those whose digestive power is energetic. The cohesion of animal food is lessened by keeping, which produces incipient decomposition, and renders it more tender and digestible. When decomposition goes beyond a certain point, however, it often causes indigestion, and commencement of decay is sufficient to render meat noxious to those unaccustomed to it when tainted. Game in this state sometimes causes diarrhœa or severe cholera, but habit has considerable power in enabling the stomach to digest such food, and there are tribes of savages that use it with impunity.

By fermentation, or what Dr. Christison has called modified putrefaction, substances of highly poisonous nature are occasionally generated in some kinds of animal food. Those kinds which have been most frequently known to acquire poisonous properties by decomposition, or the generation of some peculiar kind of ferment, are dried fish, hams, bacon, cheese, and above all, sausages, especially the German sausages.

Poisonous effects resulting from the use of sausages are by no means uncommon in Germany; and in Wurtemberg, where they are prepared from very miscellaneous articles, fatal results have not unfrequently been produced by eating sausages. The symptoms of poisoning do not usually begin till more than twenty-four hours after the noxious meal, and besides the vomiting and purging, indicating a local irritation,

there are other symptoms of more prolonged nature, which appear to show that the poison is also in some cases absorbed into the blood, and may cause a kind of fermentive action throughout the whole system. In these cases the appetite is not impaired, and fever is rarely present. The saliva emits an offensive odour. Fatal cases end with convulsions between the third and eighth day, but in cases of recovery convalescence may be protracted for years. The patient becomes emaciated shrivelled, and after death there is this remarkable and peculiarity, that the body dries up and resists putrefaction.

Those sausages only become poisonous which have been boiled before being salted and hung up, and they act as poisons only at a particular stage of decay, and cease to do so when putrefaction has advanced so far as to cause evolution of sulphuretted hydrogen.

Poisonous sausages have an acid reaction, and it was thought by some chemists that the sebacic or some other fatty acid was the poisonous agent. The poisonous matter has never yet, however, been satisfactorily separated, and the mode in which it is generated, its slow and peculiar effects on the system, and the circumstance that a boiling temperature, or the application of alcohol, which stop fermentive and putrefactive action, destroy this poison, all tend to show that it is a species of ferment. It has also been thought that the fact of its being an acid, or combined with an acid, enables it to resist the decomposing action of the gastric juice.

In this country few cases of poisoning from sausages or other poisonous meat have been observed and investigated; but Dr. Christison has stated that he thinks this arises from such cases being often allowed to pass unnoticed. In the "Association Journal," August 17th, 1855, Mr. Michael has related a case which occurred

at Swansea in a boy about five years of age, who had vomiting and purging, and died with convulsions the third day after eating one or two thin slices of German sausage.

Effects very similar to those produced by sausages have been occasionally observed from the use of bacon, dried fish, and cheese. The poisonous effects of cheese have been chiefly observed in Germany, where the curd is sometimes left to ferment till it is sour, in order that it may ripen faster; and, from the chemical changes which take place in cheese, we can easily conceive that ferments of variable nature may be generated in a substance which at one temperature causes lactic, and at another butyric acid fermentation; and that in an article of food thus prone to change a ferment may be generated of a nature similar to that of the sausage poison.

Injurious effects are less frequently produced by the articles of diet belonging to this class, which are of vegetable origin; but spoiled rye bread, barley bread, and even wheaten bread, have on the continent been occasionally known to act deleteriously and cause vomiting and purging, and other unpleasant symptoms.

We have seen that the almond contains emulsin, or vegetable casein, which has some remarkable powers as a ferment, alluded to at page 25. It is well known that almonds are very indigestible, but the bitter almond acts very deleteriously on some persons, and produces disorder of the stomach and of the whole system, which are not attributable to the prussic acid it contains, but must be due to a fermentive action being set up in the stomach by the casein acting as a ferment. In some persons the smallest quantity of bitter almond used in flavouring some articles of food, and even the sweet almond, will disorder the stomach, and cause nausea, vomiting, and purging; and in other

persons it has produced a state like intoxication, and an eruption like nettle-rash.

In a practical point of view one of the matters most requiring notice in relation to the fermentive tendencies of food is the properties of bread, according as it is fermented or unfermented. Wheat and rye are the only kinds of grain the flour of which contains a kind of gluten of such tenacity as to adapt it well for the formation of fermented bread. The kind of fermentation by which bread is raised is the vinous, and it is at first increased when the dough is placed in the oven, but is afterwards completely arrested by the high temperature to which it is subjected. When the process is badly managed, and especially when the dough is long kept, the vinous runs into the acetous fermentation, and the bread acquires a sour smell, and is then peculiarly injurious to many dyspeptics. It is well known to many persons who suffer from acidity and other symptoms of indigestion, that biscuit which has not been fermented is more easily digested and less apt to disorder the stomach than ordinary fermented bread, and this arises from the fact that bread prepared by fermentation is much more apt to pass again into fermentation, and produce the generation of acetic and lactic acids in the stomach. It is a fact, therefore, which should not be lost sight of in the dietetic management of dyspepsia, that unfermented bread is much less apt to disorder the stomach of those who suffer from acidity, heartburn, and other symptoms arising from fermentive actions.

2. Most of the compound aliments contain not only some of those albuminous principles in the previous class which act as ferments, but also saccharine and amylaceous principles — the substances which are capable of undergoing fermentive actions. Both starch and

sugar exist in many of our most common articles of food, such as the cereal grains and the potato. They are nearly identical in composition, though so different in physical properties; and it would seem to be proved, by experiments that have been made upon animals, that starch and sugar have equivalent power of fattening and increasing the weight of animals.

Starch is one of the most light and easily digested articles of food, and much used by invalids for this reason, as well as on account of its freedom from stimulating properties. Among the well known pure forms are arrow-root, tapioca, sago, and tout les mois, the last of which is very readily digested, and more agreeable to some invalids than the others. We have already shown how starch is converted by the salivary secretion, and by the pancreatic and intestinal juices into sugar.

Sugar, on the other hand, of which there are three principal varieties, viz., cane, grape, and milk sugar, is nearly in a fit state for immediate absorption; and though it seems incapable of replacing the albuminous principles and supplying the waste of the tissues, it appears to serve a very important office in the nutrition of the body, by protecting it from the action of the oxygen, by also sustaining the animal heat through its combination with the oxygen of the atmosphere, and, when not so consumed, by increasing the fatty tissues.

Saccharine and farinaceous articles of food are more easily digested than the albuminous, and they seldom disagree with dyspeptics. The use of much sugar, however, is injurious in some cases, and both sugar and starch should be rather sparingly used by those who are troubled with acidity and flatulence arising from lactic and butyric fermentation. In diabetes it is well known that sugar and starch are injurious, and sugar has been considered to be so in those dyspeptic dis-

orders accompanied with deposit of oxalate of lime in the urine.

Dr. Chambers places sugar among those articles of food which he calls arresters of metamorphosis; and he states, that from the experiments made by Dr. Böcker, it appears in its action to bear some resemblance to alcohol, and to diminish many of the secretions, more especially the urinary; and it has a remarkable power of diminishing the quantity of phosphates in the urine.

The fatty and oily substances we consume with our food are articles of diet of much more importance than was at one time supposed; and though so different in their properties and mode of digestion from starch and sugar, they appear to serve a similar final purpose in the animal economy, and to support the respiratory function. They also belong, strictly speaking, to this class, as they are substances capable of being made to undergo fermentive action.

Oil or fat seems to be an alimentary principle of essential importance for the nutrition of animals, as we find more or less of it in most of the compound aliments. The following table shows the proportions of this and the other most important alimentary principles in some of the chief common articles of diet:—

	Beef.	Eggs.	Milk.	Fine Wheaten. Flour.	Oatmeal.
Fibrin, casein, albumen, or gluten - - -	89	55	35	12	21
Fat - - -	7	40	24	2½	7
Starch or sugar - -	—	—	37	83½	70
Ash or mineral matter -	4	5	4	2	2
	100	100	100	100	100

We have seen that the gastric juice has no solvent

power over oils or fat, and that after mixing with the bile and the pancreatic secretion they become finely divided, so as to be more readily absorbed by the lacteals. Though it is well known that many kinds of fatty and oily food are heavy, and that few persons are able to assimilate any considerable quantity, it is now well ascertained that oil or fat, in certain quantity, promotes the digestion of other kinds of food. Lehmann observes, "It is easy to demonstrate by experiments on living animals, and with both artificial and natural gastric juice, that fat very much promotes the conversion of the protein bodies into peptones."

Though a certain quantity of oil or fat is thus an important or essential article of diet, and butter, therefore, not merely a seasoning agent to render our bread more palatable, as some would believe, it is not on this account always easily borne by the stomach. It is only when oil or fat is uninjured in its chemical constitution, and when taken in moderate quantity, that it can be readily assimilated. Fatty substances, by exposure to the air, undergo chemical changes, and become rancid, in which state they are obnoxious to the digestive organs; and thus we find that the same individual who can use good fresh butter with advantage, suffers severely from indigestion, acidity, and heartburn, after using that which has become at all rancid. Chemical changes are also produced in fatty substances by heat; and hence the reason that substances fried in oil or fat are prone to produce indigestion, and many kinds of pastry made with fat, to disagree with those who are dyspeptic. Dr. Pereira says, "In many dyspeptics fat does not become properly chymified. It floats on the contents of the stomach in the form of an oily pellicle, becoming odorous and sometimes highly rancid, and in this state excites heartburn, most disagreeable nausea, and eructations, or at times, actual

vomiting. It appears to me that the greater tendency which some oily substances have than others to disturb the stomach depends on the greater facility with which they evolve volatile fatty acids, which are for the most part exceedingly acrid and irritating."

We have seen that there is a fermentation called the fatty, and the changes which thus take place in oil and fat in the stomach are of this fermentive nature. We have seen that the circumstances necessary to the fatty fermentation are like those of other kinds, viz., the co-operation of an albuminous matter or ferment along with water, and a temperature of from 60° to 86°; and under these conditions a fatty acid is generated, and the oil becomes rancid. We can therefore easily understand how it is that, when fat or butter has been long detained in the stomach, it may, under the influence of the mucous secretion or albuminous matters of the food acting as a ferment, give rise to the generation of butyric and other irritating oily acids which produce heartburn, and especially if the chemical stability of the oil has been injured by previous exposure to a high temperature. Thus mutton fat may produce the acid called hircic; and butter may cause the generation of not only butyric, but of two other volatile acids, the capric and caproic, which are known to be formed in cheese by keeping.

The practical inference we would draw from these facts is this, that good fresh butter, and fatty substances which have not been injured by keeping, or chemically altered by exposure to heat in cooking, are in small quantity of essential service in promoting digestion and nutrition in most persons, but that, as they are prone to undergo fermentive action, they should be avoided or used sparingly by those who suffer from acidity, heartburn, and fermentive disorders; and such persons should especially guard against the use of butter, oil, or fat which has been injured by keeping, or such articles of

food as have been prepared by subjecting these substances to any process of cooking by which their chemical constitution is affected.

3. About three-fourths of the weight of the human body consists of water, and as it is constantly being thrown off by the skin, lungs, and kidneys, it requires to be continually renewed; and water is therefore an essential alimentary principle, and more necessary to our existence than even solid food. In the few observations we have to make on liquid aliments, we shall not, however, enter into the various uses of water, but only advert to the effect which an increased employment of water produces, by its solvent power, in augmenting the wearing away of the tissues, thereby increasing the quantity of the secretions, and either diminishing the weight of the body, if more food be not taken, or improving the appetite, by which a supply is created to obviate the increased waste. The experiments made by Dr. Böcker of Bonn on himself have not only shown this, but have likewise afforded a reasonable explanation of the action of the cold water system of treatment, which is undoubtedly of use in some chronic diseases, where an evacuating and renovating action (waste and renewal of the tissues of the body) is required in conjunction with hygienic bracing treatment. Dr. Böcker having first ascertained the exact quantity of food and drink he required to satisfy his appetite, and to maintain the body without change of weight, next proceeded to ascertain the effect of drinking an increased measure of water, and he then found that the quantity of nourishment he had been taking was insufficient to balance the loss by the secretions from the kidneys and the bowels, so that the weight of the body constantly diminished. On the days when he took the additional quantity of water (about $2\frac{1}{2}$ pints), there was more desire for food and more languor

after exercise. It would appear from his experiments, confirmed by others made by Dr. Falck, that water increases interstitial metamorphosis or destruction of tissue, and consequent loss of weight, also that the decomposed tissue is excreted partly in the urine and partly as solid fæces; and hence we can understand how a glass of cold water taken the first thing in the morning is found by some persons to act as an aperient. Whilst the appetite was augmented, it does not appear that there was any increase in the quantity of carbon excreted by the lungs. Since the use of a quantity of water beyond what is required for the performance of the functions, and what the feeling of thirst prompts us to take, has this remarkable power of accelerating the waste of the tissues, and of causing their removal by increased excretion, whilst at the same time the digestive functions are quickened, it is easy to understand that the nutrition of the whole system must be improved; and it is not, therefore, surprising that not only dyspeptic disorders, but others arising from inactive habits, and such causes as impair the activity of the excreting organs, should be greatly benefited by the abundant use of cold water, and by the bathing, the regulated diet, the exercise, and the pure bracing air with which this mode of treatment is conjoined.

Tea is a mildly stimulating drink which has become an almost universal and necessary luxury in this and some other countries, and it is consumed by a greater number of the inhabitants of the globe than any other drink prepared by infusion. Though habit and daily use render us in some measure less sensible of the soothing and reviving properties of tea, its aggregate effects upon us as individuals and as a nation must be very great, otherwise so many millions of money would not be annually expended on the purchase of it. We

know however that, besides the mere temporary gratification arising from the exhilaration of the nervous system, it has another effect, the opposite of that which pure water produces, and that it retards the waste of the animal tissues, enabling the individual to do with a smaller supply of food.

The first and most obvious effect of tea is to produce a grateful stimulating action on the nervous system, and to excite greater activity of the brain. The tendency to sleep is thus kept off for a time, and these effects are more particularly observed after fatigue. It has also an effect upon the heart, sometimes causing palpitation and irregular action; but these unpleasant effects are most apt to follow the use of strong green tea, which in some persons of nervous constitution produces muscular tremor, sleeplessness, and very distressing feelings. In those, however, in whom the nervous system is not so affected by it, green teas often agree well with the stomach, and produce a grateful, soothing effect on the digestive organs.

Tea contains three substances, on the conjoined effects of which its properties depend. The most important of them is an alkaloidal principle called theine, which is identical in composition with a similar principle obtained from coffee, and called caffeine. It is to this substance, which is present in tea in the proportion of ten grains in one ounce, that its remarkable power of arresting the waste of the tissues is due, and Liebig considers that it contributes an important part towards the formation of one of the constituents of the bile. Three or four grains of theine may be taken by most full grown persons without unpleasant effects in the course of the day, but double this quantity excites the imagination, and produces a kind of intoxication.

Tea contains a volatile oil, on which its aroma and flavour depend. It is produced during the drying

and roasting of the leaf, and it causes the exciting effects which are felt by some persons after using green tea. In China various plants are used to give to tea an artificial flavour, and the scented teas thus prepared are very apt to disagree with dyspeptic persons, who should therefore carefully avoid them.

Tea contains a third principle, viz., tannin, which is astringent, and probably more important in its effects than has been generally supposed. It exists in the proportion of from 12 to 18 per cent. in different kinds, and it must produce a decided effect on the digestive organs. We have seen that tannin has anti-fermentive properties, and we know that it combines with gelatinous and albuminous ferments, and precipitates them. It is probable, therefore, that tea tends to prevent fermentive action in the stomach, and especially when taken about three or four hours after dinner, when the digestion of the meal is nearly completed, and when its astringent action on the mucous surface must produce a beneficial tonic influence, and restrain unnatural mucous secretion.

Dr. Böcker made experiments with tea similar to those we have already noticed as having been made with water, and from them it appears that tea has the reverse effect of simple water, and tends to arrest the waste of the tissues. In ordinary doses he found that it had no sensible effect on the pulse, the respiration, or the quantity of carbonic acid given off from the lungs. It had this remarkable effect, however, that when the diet was insufficient, it limited very much the loss of weight thereby entailed; and this affords some explanation of the fondness of females, who are unable to obtain a sufficient supply of nutritious food, for tea. He found that it diminished the loss of substance in the shape of urea, and also the secretions from the skin and bowels. We may conclude, therefore, that when

sufficient food is used, the body is more likely to gain weight when tea is taken than when not.

“No wonder, therefore, that tea should be a favourite, on the one hand, with the poor whose supplies of substantial food are scanty, and, on the other, with the aged and infirm, especially of the feebler sex, whose powers of digestion and whose bodily substance have together begun to fail. Nor is it surprising that the aged female, who has barely enough of weekly income to buy what are called the common necessities of life, should yet spend a portion of her small gains in purchasing her ounce of tea. She can live quite as well on less common food when she takes her tea along with it; while she feels lighter at the same time, more cheerful, and fitter for her work because of the indulgence.”

Coffee yields an infusion which produces stimulating effects on the nervous system similar to those of tea. It excites and arouses, and keeps off sleep, and hence it is often resorted to by those who study at night. After fatigue it refreshes, and gives a feeling of repose and comfort, and it has the same power which tea possesses of diminishing the waste of the tissue, and the demand for food. From its power of arousing and keeping off sleep, it has been used to counteract the stupor produced by opium and alcoholic liquors. It acts beneficially on the nervous system in some cases of asthma. It has a more stimulating effect on the circulation than tea, and it is a wholesome beverage, which in some persons agrees better with the stomach.

It contains three chief ingredients, similar to those present in tea, viz., caffeine, which is almost identical with theine; a volatile empyreumatic oil, which is generated in the roasting; and more or less of an astringent tannin principle. The volatile oil, when given by itself,

was found by Dr. Julius Lehmann to produce an exhilarating action on the brain, affecting the imagination less than the reasoning powers. It moved the bowels, and caused perspiration, but it dispelled hunger and arrested the waste of the tissues as much as caffeine. It would therefore seem to be quite as powerful a stimulant as the latter principle, the effects of which are the same as those of theine. The tannin principle of coffee is altered by roasting, and its astringent action is therefore weakened in proportion to the degree of heat to which it has been subjected.

With respect to the action of coffee on the digestive organs, we would observe, that the infusion of the roasted berry has very decided antifermentive properties, to which are no doubt due the power which Dr. Ure states that strong coffee has of counteracting the effects of sausage poison. The tannin principle may have some antifermentive action, such as is produced by the astringent principle of tea, but it is very much altered and destroyed by roasting. Its antifermentive power is, however, due more particularly to the empyreumatic oil, and as this principle is increased by exposure to a high temperature, the antifermentive power of highly roasted coffee must be greatest. If heated so far as to char the berry, the charcoal generated will probably also exert a similar influence. Coffee is therefore a beverage which must exert a very salutary influence upon the stomach in many of those disorders where there is a fermentive tendency; and as highly roasted coffee has stronger antifermentive power than tea, it may be substituted with advantage for tea in some of these dyspeptic disorders. It is somewhat strange, that though the properties of these very common kinds of liquid aliment have been so very closely examined and discussed, little or no notice has hitherto been taken of their

antifermentive action on the stomach and digestive organs.

Cocoa is more a nutritious than a stimulating beverage, but it contains a principle similar to theine and caffeine, which is called theobromine, and also empyreumatic oil. The quantity of fat it also contains renders it a less suitable article than either tea or coffee in most of the fermentive disorders of the stomach.

Tea and coffee have come into more general use as the intellectual activity of the leading modern nations has developed itself; and, from the preceding observations, it would seem that they are not only harmless, agreeable, and cheering kinds of stimulants, but that they tend to prevent abnormal fermentive actions in the stomach, which are more apt to occur in highly civilised states; and it would also appear that, by preventing the wearing out and waste of the tissues, they save the necessity for so large a quantity of the nitrogenous articles of food, such as meat, bread, and milk, and that they are, therefore, indirectly nutritious.

Fermented and *alcoholic* liquors constitute a kind of aliment for which there is a universal desire among mankind in every state of society, savage as well as civilised, and the utmost ingenuity has been displayed in every part of the globe in preparing such stimulants in order to obtain the excitement and gratification they are capable of yielding. Like all other potent agents which produce pleasant excitement, alcoholic liquors are liable to abuse, and strong arguments, drawn from the evils caused by their excessive employment, have been advanced against their use in moderation. Whilst we acknowledge these evils, and admit the seductiveness of alcoholic stimulants, and whilst we would likewise caution those who value the blessing of health against the abuse of them, we should not allow such arguments to have any weight with us in

preventing the right and temperate use of these agents as food, medicines, or as stimulants to renovate the body when depressed by fatigue, or the cares and anxieties of life. Our existence is made up of excitement and depression, and is fraught with pleasure and pain; and wine, "which maketh glad the heart of man," and the other alcoholic stimulants generated by spontaneous fermentation under some circumstances, have been placed within the reach of man in order that, as an intelligent being, he may discover their uses, whilst he avoids the abuse of these as he would the abuse of any other potent agents. Tea and coffee are harmless stimulants, the utility of which is universally acknowledged, and yet the excessive use of them, and even of food itself, will produce injurious effects.

There is very considerable difference in the effects produced upon the stomach by the different kinds of fermented liquors, and by spirituous liquors.

All kinds of fermented liquors in which the action of fermentation is still going on are apt to disagree with those dyspeptics who suffer from the forms of indigestion which arise from fermentive actions in the stomach. Those imperfectly fermented liquors are especially apt to disagree with them which contain much unfermented saccharine matter, starch, or gum. The milder and newer kinds of ale and porter which contain such fermentable substances produce flatulence and distension, from the renewal of the vinous fermentation and the disengagement of carbonic acid in the stomach, whilst the older and harder kinds are more apt to produce acidity from lactic and acetous fermentation.

All fermented liquors are liable to contain acetic acid generated by acetous fermentation, and in malt liquors it is the only acid met with. In other kinds,

however, it is not the chief acid, for in wine the acidity arises from tartaric acid; and in cider and perry, and in the beer made from milk, and from millet, lactic is the acid to which these liquors owe their acidity. As lactic acid has digestive power, we can therefore understand how it is that cider and perry should be wholesome drinks, which in many persons assist digestion.

It is well known that wine is less apt to disagree with dyspeptic persons than the less perfectly fermented drinks we have alluded to, and also that old dry wines, in which all fermentive action has ceased, are the most suitable kinds for persons who have weak digestive powers; whilst, on the other hand, new and sweet wines are liable to excite fermentive actions, and cause acidity, heartburn, and other dyspeptic symptoms. It is well known that champagne and other effervescing wines disagree with many persons, and this arises from the fact that the fermentation is still going on in such wines, which has, therefore, a powerful tendency to excite fermentive actions in the stomach. There is no wine that combines the two qualities of dryness and freedom from acidity to a greater degree than sherry, which is therefore one of the wines most generally admissible for those who suffer from indigestion; but there are some for whom port is better adapted, owing to its astringent action on the mucous surface of the stomach.

The stimulating properties of all fermented liquors are owing almost entirely to the alcohol they contain. Their injurious effects on dyspeptics are due, however, not so much to the alcohol as to the fermentable matters combined with it; and they consist of saccharine, gummy, and starchy matters, and of azotised ferments, which are in a transition state, and excite fermentation in the food contained in the stomach.

Pure spirit, on the other hand, is itself an anti-

fermentive and antiseptic agent, and brandy is, therefore, often added to wine to prevent fermentation, and preserve it; and this shows how it is that brandy and water should agree better with many persons who suffer from indigestion than wine or fermented liquors; and it affords a reasonable explanation of a dietetic precept which experience has long sanctioned in many forms of stomach disorder.

The purpose which alcoholic liquors finally serve in the animal economy is probably, as Liebig endeavoured to show, that of combining with oxygen to support respiration, and serving as a source of animal heat. It is difficult to understand how it can act otherwise than in this way; for though the quantity of carbonic acid and watery vapour thrown off by the lungs is not increased by the use of fermented liquors, but is, like the other secretions, diminished, we also know that alcohol does not pass off from the lungs or with any of the secretions in an undecomposed form in any quantity worthy of notice.

Alcoholic liquors diminish the waste of the tissues, and, like tea and coffee, they lessen the demand for food; and hence we find that persons who indulge much in spirits or fermented liquors eat but little comparatively, whilst, on the other hand, teetotallers eat largely, and are said to consume much farinaceous food.

The secretions are also diminished by alcoholic liquors, more especially those of the kidneys and lungs. From Dr. Böcker's experiments, it would seem that the diminution of the urine, both of the whole average quantity of the fluid, and of the solid constituents, amounted, under the influence of a certain quantity of alcohol, to four-tenths of the average quantity. At the same time it did not increase the cutaneous secretion, or that from the bowels. The quantity of carbonic acid thrown off

from the lungs was diminished, and the watery vapour was not increased.

Alcoholic liquors are, therefore, it would appear, important articles of food which limit the waste of the tissues; and it is a fact worthy of notice, to which the author of the "Chemistry of Common Life" has drawn attention, that in comparing the quantity of alcoholic liquors consumed in England, Scotland, and Ireland, the average consumption for each individual is least in Ireland, where there is the greatest amount of intemperance, and greatest in England, where it is said that there is least intemperance. The consumption, which is much greater in England, would seem to bear a relation to the material prosperity of the country.

The writer of an able article on the "Physiological Errors of Teetotalism"* regards alcohol as the generator of force; and Dr. Chambers has drawn attention to its prophylactic effect against the destructive energies of the mind: — "It is," he observes, "unnecessary to quote proverbs in all tongues to show how work purely mental exhausts the body; how, for instance, not only the painful emotions, care, sorrow, anxiety, but also the nobler enthusiasms, the afflatus of the poet, the ambition of the patriot, the fixed attention of the scholar, the abstraction of the lover, fret to dust their tenement of clay. Whether this arises from defective assimilation, or increased destruction in the tissues, is not known, and does not affect the argument. Animals have not these causes of friction in their machinery, and require no defence against them; but we all of us daily experience them, sometimes in a pleasant, sometimes in a painful degree, and, to soothe our moved minds, instinctively or rationally adopt some of the remedies which nature and art afford." †

* Westminster Review, July, 1855.

† Digestion and its Derangements.

It would seem that though there is considerable resemblance in the effects of wine and beer to those produced by alcohol, there is considerable difference in their effects on the secretions arising from the other matters combined with the alcohol in these liquors. Thus beer was found to cause an increased excretion of chloride of sodium in the urine, but wine augmented the proportion of earthy phosphates.

4. Of the seasoning agents, or condiments, the most important requiring notice in reference to their influence on fermentive actions are common salt, mustard, and horse-radish, garlic, and the spices, such as pepper. Most of them have more or less antifermentive power; and if we except common salt, which, in addition to its antifermentive power, has other more important uses in the economy, it would seem highly probable that the chief use of many seasoning agents such as mustard, which has hitherto been a mystery, is not merely either to gratify the palate or to stimulate the stomach, but to arrest the tendency to abnormal fermentive actions.

Common salt, which exists in the water we drink, as well as in most kinds of food, is essential for the life of man and many other animals, and a quantity exceeding what naturally exists in the food tends to promote health and nutrition. Besides furnishing, by its decomposition, the hydrochloric acid of the gastric juice and the soda of the bile, it forms an essential constituent of the blood; and it is a singular and interesting fact, that whilst salts of soda exist in the blood with only traces of those of potash, the juice of the flesh contains salts of potash only.

Salt renders albumen more soluble, and hence meat has more taste when eaten with salt. Having antiseptic properties, it is used to preserve meat, and it is also an antifermentive agent of some power; and we have seen that it was found useful in a case of fermen-

tation with vomiting of sarcina. When taken in increased quantity, it would seem to have the power of augmenting the proportion of urea in the urine; and Dr. Chambers regards it, therefore, as one of the agents which promote metamorphosis or waste of the tissues. It is the chief saline ingredient in many mineral waters, the alterative and deobstruent virtues of which are no doubt in a great measure due to the common salt they hold in solution. The addition of salt to the fodder of oxen improves their health and appearance, and more particularly that of the hair.

Dr. Chambers says the employment of salt, therefore, in the average healthy state, is decidedly beneficial to the human species, and the use of it, as an accessory aliment, is wise in those who are well supplied with other food.

Mustard is one of the condiments most extensively used; and as it has alone a very pungent disagreeable taste, we cannot doubt that it would not be instinctively sought after and consumed with our food, if it did not serve some useful purpose. That this purpose has not, however, been hitherto unravelled would appear evident from the following observations of the late Dr. Pereira:—

“The relish for flavouring or seasoning ingredients, manifested in a greater or less degree by almost every person, would lead us to suppose that these substances serve some useful purpose in the animal economy beyond that of merely gratifying the palate. At present, however, we have no evidence to prove that they do; they stimulate, but do not seem to nourish. The volatile oil which they contain is absorbed, but is subsequently thrown out of the system, still possessing its characteristic odour. A portion of it may, perhaps, be burnt in the lungs, and in this way produce heat.”

Before discussing the use of these agents, and offering

my own view of the subject, I would observe that mustard is the ground seeds of the *Sinapis nigra*, a plant of the natural family of the *Cruciferae*, one of great importance in an economical point of view, and to which belong many of the vegetables cultivated in our gardens, such as the cabbage, common cress, horse-radish, rape, and scurvy grass. In former times, when scurvy was a common disease in spring, many of the plants of this natural family were highly valued on account of their antiscorbutic properties, and some of them are still used and considered depurative and wholesome when eaten as salad.

Many of them have, especially in the wild state, a pungent taste, which is due to an acrid volatile oil. It is the same acrid oil which gives the pungent taste to mustard and to horse-radish, and probably to all the other plants of this family. It is one of the sulphuretted essential oils, having the composition of sulpho-cyanide of the radicle allyle, which we shall presently see to be the radicle also of the oil of garlic. It is known to chemists that sulphuretted oils check fermentation; and I was therefore led to try the effect of horse-radish and mustard, and I found that both have this property, and that mustard is one of the most energetic of all the antifermentive agents in arresting both the vinous and the lactic fermentation.

These facts throw light on the purpose which mustard, horse-radish, and similar seasoning agents serve; they furnish the most satisfactory explanation that has yet been given of their action on the economy; and I think we can entertain no doubt that the use of these acrid condiments along with our food is to arrest the tendency to abnormal fermentive actions in the stomach.

Garlic is another kind of seasoning agent distinguished by its strong and, to many persons, disagreeable smell.

It is a plant of the natural family of the *Liliaceæ*, to which belong the leek and the onion; and the strong smell of these plants is due to the same sulphuretted volatile oil, which exists in larger quantity in garlic. This oil is a sulphuret of the same radicle allyle which exists in the volatile oil of mustard; and Dr. Ure places garlic along with mustard and horse-radish, among the agents which stop fermentation. It is not, however, by any means as powerful an antifermentive agent as mustard; and though it may have some power of checking certain kinds of fermentive action, I was rather surprised, in my experiments with both the garlic itself and with a tincture of it, to find that the evidences of vinous fermentation were not diminished, but rather increased. Can it be that, like alum, which stops the viscous fermentation, but increases the activity of that which occurs in the baking of bread, garlic may advance the vinous and yet retard some of the other kinds of fermentation?

Assafoetida is the concrete juice of a plant belonging to a different natural family; and though it is distinguished by a fetid and still more disagreeable smell than garlic, it is a singular fact that on the borders of Asia it is extensively used along with the food as a condiment. It is another singular fact that the essential sulphuretted oil or oils which it contains have also allyle as their radicle or base, and there is said to be no difference between the essential oils of garlic and assafoetida, except that the oil of the latter contains more sulphur. In my researches I found that assafoetida had a decided power in restraining the vinous fermentation, though it was less active than mustard.

It is a singular coincidence, as remarked by the author of the "Chemistry of Common Life," "that without any knowledge of their close chemical relations among the plants in question, different races of men in different

parts of the world have long selected and largely used them as condiments to their food. The Englishman to a certain extent relishes his onion, and the Frenchman mildly flavours his more savoury dishes with a touch of garlic or *chalot*. But in Portugal and Spain the onion and the garlic are the relishes of common and every day life. This taste the Peninsula has probably acquired from Northern Africa. Over the whole of the latter region — from the shores of the Mediterranean to the sources of the Nile — garlic and the onion are most esteemed seasoners of the universal food. Arab, Moorish, and Ethiopian tribes equally delight in them, and this taste is of very remote origin. The Israelites, during their sojourn in the wilderness, murmured, saying, ‘we remember the cucumbers and the melons, the leeks, the onions, and the garlic.’ Among the ancient Egyptians themselves, the onion formed an object of worship; and the modern Egyptians assign it a place in their paradise. To the present day, the onion of the Nile borders possesses a peculiar excellence and flavour. The Eastern Asiatics appear to require more powerful condiments. With them the *assafœtida* takes the place both of the milder onion and of the stronger garlic.”

The sulphuretted essential oils contained in the seasoning agents to which we have referred are the most potent in checking fermentive actions, but the other essential oils have also some antifermentive power, and it is probable that pepper, cloves, and other spices containing volatile oils tend to produce a similar effect, though it is evident that this cannot be the sole use of those more palatable seasoning agents.

In this chapter and throughout the treatise I have endeavoured to examine the disorders of digestion in as practical a point of view as possible, and to confine my investigations to those arising from fermentive actions;

but enough has been incidentally advanced to show also that fermentive actions have a more extended bearing on the origin of other diseases, and that these actions are deserving of more profound and exact study on the part of both the chemist and the practical physician. Medicine is one of the uncertain sciences, and from its nature will necessarily retain always more or less of this character; but chemistry, and especially the organic branch of it, is the science from the progress of which, and its application to medicine, physiology, and therapeutics, we have reason to expect that it will gain a greater degree of exactness; and in these researches I have endeavoured to bring the one science to bear practically on the other, and I would point to the deduction I have drawn as to the connection between antifermentive power and the power in some remedies of relieving gastric pain, and sickness and vomiting, and also to the explanation I have given of the uses and action of some condiments which have been proved to be energetic antifermentive agents, as examples in the preceding pages of what appears to me to be a legitimate and successful application of chemical facts to the practical advancement of medical knowledge.

THE END.

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"These things surely teach us a lesson of no little importance; they cannot but tell us that despair is unwise, that we may hope even for our consumptive patients; and that, hoping, we are bound to use all the appliances which our art makes known, — medical, hygienic, climatic, — to bring about what some will call an *arrest*, what others will designate by the more cheering name of *recovery*, but what, call it as we may, is in numberless instances, a priceless boon." Jan. 1851. Vol. vii., p. 175.

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